Using a cognitive model to study and design collaborative learning with cases

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A dissertation submitted in partial fulfilment
of the requirements for the degree of

Doctor of Philosophy
of the
University of London

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January 2008

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Abstract

The thesis investigates learning in small-group case-centred discussions, and develops and validates guidelines for its improvement (including guidelines for educational technology). The thesis is the only in-depth study on case-centred discussions in a current educational practice from the perspective of cognitive learning theory. Notably, the approach it takes is to adapt theories of learning from cognitive science to a group setting. The significance of the contribution is in improving our understanding of the relationship between dialogue and learning, and the particular mechanisms involved in the co-construction of abstract representations leading to learning.

The thesis approached the study of the relationship by developing frameworks and analysis techniques for eliciting processes of interpretation, conceptualisation and explanation. Dialogues are analysed in terms of how interpretations for cases are jointly constructed, what knowledge is used by learners to construct them and what knowledge is acquired as a result of this activity. It hence analyses distinctly the content of utterances and describes how this content is appropriated and transformed by the learners. Through this analysis, the thesis showed, for example, the correspondence between individual and collective views about a situation.

One set of data was collected in a field study: 12 case-centred discussions of 1st year undergraduates on medical ethics and medical law at UCL medical school were videotaped and transcribed. From the analyses I was able to show that the learning design is ineffective in promoting the development of new explanations that would reflect a deeper understanding of the domains of ethics and law. However, students construct relational knowledge (e.g. relations between similar cases) and acquire knowledge about when to apply known lay concepts.

On the basis of these findings, a new design for collaborative learning with cases is proposed. It specifies the learning material (a set of structurally similar cases; the inclusion of an expert opinion and explanation) and the learning task (a justification task). The design is validated in a study (12 discussions): the analysis shows that the discussions are more effective than in the field studies because students are able to overcome initial lay explanations and develop more expert explanations. More specifically, the students are able to structure their explanations for the cases around the intended core concepts.

The thesis' originality lies in using concepts of classical cognitive science to describe the co-construction of knowledge in small groups. By relying strongly on a theoretical framework, the thesis shows that the theory/practice dichotomy can be effectively overcome, and that a deep theoretical reflexion on educational practice can be very relevant for the understanding and enhancement of that practice.

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Acknowledgements

I'd like to thank my supervisor, Dr. John Dowell, for providing wise and expert guidance throughout the research and compilation of the thesis, and for the many productive and patient discussions on the topics pertinent to it. His insights into cognition and learning will accompany me for quite some time.

Special thanks go to many 1st year undergraduate medical students at the UCL medical school who graciously accepted us during their courses, and permitted us to videotape their discussions. Clearly, it is hoped that the results from this thesis will help to understand and maybe improve their education. Many thanks also to the tutors of said courses who gave us that invaluable and rare access to learning-in-the-real-world.

Thanks also to my erstwhile collaborator on the field studies, Tony Lambie, for his discussion and critique. My friends in London, especially John, Emma, David and Sacha, provided company, and valuable tips and help.

This thesis is dedicated to my parents. I want to thank them for their immense support over the years.

Chapter 1

Introduction

1.1 Research aim

The aims of this thesis are to improve our understanding of the educational practice of the case method, and to develop a specification for an improvement of the practice. These aims are accomplished by, first, developing a descriptive and qualitative characterisation of small-group case-centred discussions, and, second, by proposing and validating an improved learning design for the practice.

The thesis analyzes in detail 2 discussions on medical ethics cases (cases of euthanasia) held within the undergraduate medical curriculum at UCL, and describes the ways in which the students jointly develop interpretations and explanations of the cases. It further presents a qualitative characterisation of the learning outcomes of the discussions, and, based on that characterisation, proposes an improvement of this form of learning. The improvement is demonstrated and validated in a design experiment with participants drawn from the original student pool. The thesis' contributions to research on the case method are grounded in data gathered in an authentic educational setting, as well as in data collected in a study of high ecological validity.

The case method, an educational method where students discuss collaboratively complex real-world situations (see appendix 1 for an example of a case), has a long history in education aimed at professional and postgraduate education in business, management, law and medicine. Lately, a similar approach, problem-based learning (PBL; Barrows, 1985) is used also in undergraduate education. This expansion is a result of, among other reasons, the increasing recognition of the educational effectiveness of collaborative learning with real-world situations. Case- and problem-based learning share, among others, these two essential features but are distinct in that cases present solutions and outcomes.

However, understanding of how learning with cases occurs and how it could be improved has received no targeted specific attention in the learning sciences or cognitive science community. Especially the understanding of the case method is underdeveloped. For example, recent descriptive and evaluative research (e.g. Burgoyne & Mumford, 2001) found that research on the case method focuses on educational and pragmatic dimensions at large, such as the kind of cases used, the way tutors support a discussion, and the generic learning outcomes. Little use has been made of learning theories to evaluate the potential as well as assessing the effectiveness of the case method (Mumford, 2005). There is, for example, uncertainty about what is learned through the case method, whether it is substantive domain-specific knowledge, or knowledge about how to apply domain-specific concepts, or argumentation, decision and communication skills (see section 2.2.3). Also much of the effectiveness of the case method is linked to the skill of the facilitator to direct students learning toward the understanding of the main story of the case. That students may learn from engaging with the case material, and engaging in intense discussions with peers is normally not acknowledged. The lack of understanding of the case method and specifically about the learning processes and learning outcomes constitutes a problem also for proposals to implement a distributed computer-based form of the method. Indeed, as Koschmann et al. (1996) have argued, the design of such environments should be in part based on models of existing practices.

1.2 Research object

The essential characteristic of the case method is the following: students are given complex real-world situations to discuss, and are expected to use their conceptual knowledge to interpret and analyse the situations. Students are expected to increase their understanding about real-world situations in order to become better problem solvers and decision makers. Typically a case would be the basis for learning in distinct stages, the important ones being self-study, small-group discussion, and plenary discussion. In each of these stages, learning occurs. For example,

during self-study, a student may read the case thoroughly, selects what she deems to be the relevant background knowledge to interpret the case and attempts a first individual interpretation of the case. In the small-group discussion, individual interpretations are discussed, and in the plenary discussion, small groups present their conclusions to a larger audience.

This thesis focuses on small-group discussions. Small group discussions are deemed to be the most important stage within the case method at large. Real-world applications of the case method emphasize this stage over the others, and occasionally it is even the only stage. Small-group discussions promote valuable learning gains, and are regarded as a particularly effective form of learning. The collaborative and small-group setting permits students to bring in their viewpoints, have them individually challenged by their peers, and to construct jointly new knowledge. Learning, in this setting, is an intense experience, characterised by several dialogical processes (such as argumentation and negotiation) regarded as being particularly conducive for learning (cf. Andriessen, Baker & Suthers, 2003)

1.3 General research approach

Educational practices can be studied in several ways. For example, researchers may develop descriptions of a practice by observing and recording how students engage with the learning material, how they make use of tools and objects of the learning environment, and how they interact with the tutor and their peers. From the careful analysis of these recordings, insights can be gained about the features that are critical for successful learning. For example, these analyses allow inferring which aspects of the learning environment are appropriate in supporting the learners' activities (Scardamalia & Bereiter, 1994, Salomon, 1998), how different environments lead to differences in learning outcomes (e.g. Suthers & Hundhausen, 2003) and how to redesign parts of the practice (e.g. Cobb, McClain, K., & Gravemeijer, K., 2003). Within this general agenda to analyse real-world learning, recently several studies have focussed on social interactions. These analyses identify, for example, whether and how tutors scaffold the students' learning, or whether the students' discussions are productive and coordinated activities (e.g. Barron, 2003). Measures so gained are then used to design collaborative learning (e.g. Howe et al., 2007) or compare differences in dialogue structure and dialogue moves across environments (e.g. Veerman, Andriessen & Kanselaar, 1999).

Almost all this research relies on detailed qualitative analyses augmented by statistical descriptions of the data body. Conclusions about differences in learning rely then on differences in interaction structures, processes, etc. For example, some interactions (e.g. argumentations, cf.

Andriessen, Baker & Suthers, 2003) are deemed to be more productive for learning than others, and the relative frequency of such kinds of interactions are used as the basis for claims about the overall 'quality of learning'. Much less research relies on objective post-session assessments of learning gains, though some advances in this direction have been made (e.g. Kneser & Ploetzner, 2001; Philips & Tolmie, 2007). The reason for the emphasis on qualitative analyses combined with descriptive statistics and inferences on learning (rather than objective post-session assessments) are theoretical, but also methodological, as indeed the analysis of educational dialogues in particular is a relatively recent development in learning research. Indeed, research on educational dialogues has up until now developed methodological tools that need further refinement in order to be able to be used on large data sets. For example, the inability of analysis tools to identify argumentation structures in educational dialogues may be due to the instrument rather than to the students' lack of argumentation. Thus, instruments for the qualitative analysis of a large data body gathered in an authentic educational context must first be refined so that they allow quantifications and inferential statistical elaborations upon whose basis then relations between dialogue aspects and objectively assessed learning gains can be identified (elements of such a method have been proposed in Phillips & Tolmie, 2007).

The general research approach in the thesis needs to be seen with this current state of research on educational dialogues. It contributes indeed to the advancement of the qualitative analysis of dialogues and presents a descriptive characterisation in terms of learning processes (which processes are most frequent). Learning outcomes are then proposed in the form of qualitative characterisations of the learning outcome, rather than, for example, quantitative assessments of learning gains. Further specifics of this approach and its implication are discussion in section 1.8.

1.4 Research questions

The aims of the thesis, to contribute to the understanding of collaborative learning with cases, and propose an improvement of current practices, are reconceptualized as research questions. They are the following:

1. how do students learn
2. what do students learn
3. how well do students learn
4. what should be done to improve learning

These are clearly very generic formulations, but they do provide the foundation of more the specialised questions answered in this thesis. That is, this thesis proposes to answer these

question on the basis of specific assumptions on what is intended by learning, on how learning occurs and what may count as learning. These assumptions are presented now.

1.5 Central assumptions of the thesis: the view of learning

The research in this thesis has been influenced by the view of learning as the active construction of knowledge occurring in the social plane that engenders improvements in understanding of the cases and the domain of study. In particular, the thesis studies how a group of learners processes information (the learning material) and knowledge to construct an abstract representation – such as an interpretation, conceptualisation or explanation – of the cases. It analyses in particular which cognitive processes – such as abstraction, generalisation, and relationing – learners use to construct a meaningful, coherent understanding of the cases, and which 'cognitive products' – such as the deep structure of a case or distinctive domain-specific features – result from this processing. By studying in detail this processing, the thesis adopts the view that the group is a single cognitive system and that the processing of knowledge and information is distributed over several group members with the final 'product' (e.g. the case structure) being the joint product of the group.

The thesis thus incorporates assumptions and findings of cognitive science with the view that learning is the active and social construction of knowledge. It relies on cognitive science research to describe *how activities observable in the social plane lead to better understanding and new conceptualisations* and is in line with research such as Chan, Burtis & Bereiter, (1997), Roschelle (1992) and Duit et al. (1988).

Pea's (1993) proposal to relate the observation of learners' activities to conceptual change provides a general formulation of this line of research. He distinguishes the visible aspects of learning and the invisible background. The visible aspects are the learners' interactions with artefacts and their interactions with the teacher and other students. The invisible background is the domain structure, the expert description of problems, and the students' own knowledge that the learning activities are poised to modify. He then proposes that the fundamental question of learning research should be the following: how do the visible and the invisible come together? How do the interactions result in a modification of the learners' conceptual structure?

Some proposals have been advanced to answer these questions. For example, research may rely on an analysis of negotiations and relate it to a description of the elaboration of knowledge (e.g. Baker, 1996). Dialogues would be analysed in terms of interactional processes (such as requests for clarification or elaboration, or repairs), but crucially, these processes are related (they sometimes entail) to the appropriation of new knowledge or meanings.

A most prominent embodiment of the attempt to relate learning activities with observable changes in learners' knowledge, and the one most central to this thesis, is the analysis of a dyad's learning accomplishment described in Roschelle's (1992) study. There, the assumptions of learning as being mediated through activities manipulating information in the environment finds its expression in the description of the learning accomplishment as the acquisition of a novel conceptualization of a problem. The study assumes that the social and practical environment scaffolds the construction of that new (and better) conceptualization, and the new conceptualization constitutes then a novel cognitive product. The following two assumptions on learning in Roschelle's study constitute the two basic assumptions for this thesis:

1. the students' activities are interpreted as manipulations of external objects, whether they are concrete (the display of the problem situation) or 'virtual' (an idea, conception or knowledge introduced earlier by a peer).
2. learning intended as the outcome of the learning session is ultimately evidenced as a new understanding of the problem situation, evident as a new conceptualisation of it. In particular, the labelling of literal features of the problem situation functions in the study as evidence for an internal restructuring of conceptual knowledge, i.e. of conceptual change. That is, claims about learning outcomes are justified on the basis of changes in the learners' description of problem situations

This study, considered a seminal contribution to the understanding of collaborative learning, combines thus a view of learning as a constructive social activity with a view of learning as the change in the description of the problem engendered by the activities and occurring in the course of the discussion. The change is identified by relying on a normative model of the description of the 'deep features' of problem situations: specifically, it relies on the consistent finding that more expert problem solvers are able to see through these surface features and attend to relational structures, in contrast to novice problem solvers who describe problems in surface features (Chi, Feltovich & Glaser, 1980). Conceptual change, the broad phenomenon of learning investigated in this study, is thus the registering of the 'deep features' of the situation.

In line with this research, the analytical foci of the thesis are cognitive processes, knowledge products and novel understandings (conceptualisations) that may emerge from the information-processing activities of the group. Thus, the analysis of the discussions identifies the kinds of cognitive processes used by learners, the kind of knowledge products constructed by these processes, and the changes in the description of the problem situations occurring over the course of the discussion. To further advance the study of collaborative learning from the assumption of the group as a single cognitive system, another analysis identifies the mechanisms of the introduction of new knowledge into the discussion.

The assumption of the group being the unit of analysis is further specialized in this thesis as follows: (1) it is assumed that the processing of information and knowledge leads to the identification of the deep structure of the case discussed. This structure represents the case as the single 'core point', the main 'story' or the 'morale' embodied by the case (cf. Schank, 1983; Gentner, 1989; Gick & Holyoak, 1980). This view is consistent with assumptions in cognitive science that people aim to construct a coherent and meaningful representation of problems, stories, examples, etc., the structure indeed embodying the meaning of a story; (2) it is also assumed that when developing/identifying the structure of the case, learners rely on a variety of kinds of knowledge such as factual knowledge, conceptual knowledge (domain-specific or lay) and episodic knowledge (such as personal experiences). Episodic knowledge may be superficially (near cases) or structurally (far cases) similar to the case discussed; (3) further, in line with the core assumption that people and their environment constitute a single cognitive system (the person-plus view, Perkins, 1983), the assumption is made that individual members use their own knowledge as well as knowledge conveyed in contributions by others as if they were their own cognitive resources (the hypothesis of equivalent access, Perkins, 1983). That is, learners build on their own knowledge as well as knowledge available in the social plane (i.e. that are part of the conversation); and (4) to identify the mechanisms by which new knowledge is introduced into the discussion, the knowledge bases of the individuals is interpreted as a single knowledge base operating according to the mechanisms of knowledge retrieval through cuing.

With respect to the thesis' contribution to the improvement of collaborative learning with cases, the following assumptions are made. In this thesis, the conditions for learning are investigated within the notion of 'learning design'. Design is intended here as a 'blueprint' or 'template' that can serve as the basis for a further specialisation in the form of an adaptation of the general guidelines to local conditions.

The concept of 'learning design' includes the learning material, the task set and the environment within which learning takes place (the way learners communicate and the form of display and use of the learning material). This definition of learning design is consonant with the systemic notion of a learning ecology (Cobb et al., 2003), i.e. the view that a learning system is a set of interacting components that together are able to 'engineer' a specific form of learning (Brown, 1992). The learning outcomes are attributed to the learning design as a whole, i.e. to the complex interaction between the content of the learning material, the task, the display and accessibility of relevant knowledge, and also to the communication media.

1.6 Specific research questions

Given these assumptions, the central questions addressed by this thesis are: what processes do students employ when attempting to derive a conceptualisation, interpretation or new representation of the case; what knowledge do these processes construct; and, how should learning activities be promoted and supported by a learning environment so that a specific kind of knowledge is acquired.

The following list presents the specific questions in detail.

Question 1: how do students learn?

- which cognitive processes do learners employ to process knowledge and information?
- what are the mechanisms by which knowledge is brought into the discussion?

Question 2: what do students learn?

- which knowledge structures do the students construct? What knowledge, other than the case structure, is constructed or undergoes change during the discussions?

Question 3: how well do students learn?

- do the students experience conceptual change as a result of engaging with the learning material?
- in consideration of the knowledge constructed, what are the overall learning outcomes of the discussions?

Question 4: what can be done to improve it?

- which features of the learning design of the analysed discussions are related to the learning outcomes?
- what modifications of the design would improve this form of learning

1.7 The specified aims

The research aims can now be specified more in detail. Main aim 1, to present a descriptive characterisation of the discussions in terms of learning processes and mechanisms of the introduction of knowledge, and characterise qualitatively the learning outcomes, is subdivided into four sub-aims:

1.1. to develop a framework of the most common cognitive mechanisms employed when people learn with complex problems and examples, and the kind of knowledge constructed by these processes. This framework is a synthetic account of the research on the cognitive mechanisms of learning from solving problems and studying examples.

1.2. to develop analytical instruments (coding schemes) to identify (1) the cognitive processes and (2) the mechanisms of the introduction of knowledge; these instruments are specified as a set of indicators, such as keywords or tell tale signs.

1.3. to analyse the discussions using the coding schemes, and to present a descriptive characterisation of the dialogues in terms of these mechanisms (i.e. which processes occur with which frequency); and to identify whether the discussions engendered conceptual change.

1.4. to present a qualitative characterisation of the learning outcomes on the basis of the occurrence of conceptual change and on the basis of knowledge constructed

Main aim 2 is subdivided into 2 sub-aims:

2.1. to propose a learning design that addresses shortcomings in the learning outcomes

2.2. to demonstrate and validate the learning design

Figure 1 is a map of the thesis organised around the research aims and the thesis chapters/sections where those aims are achieved.

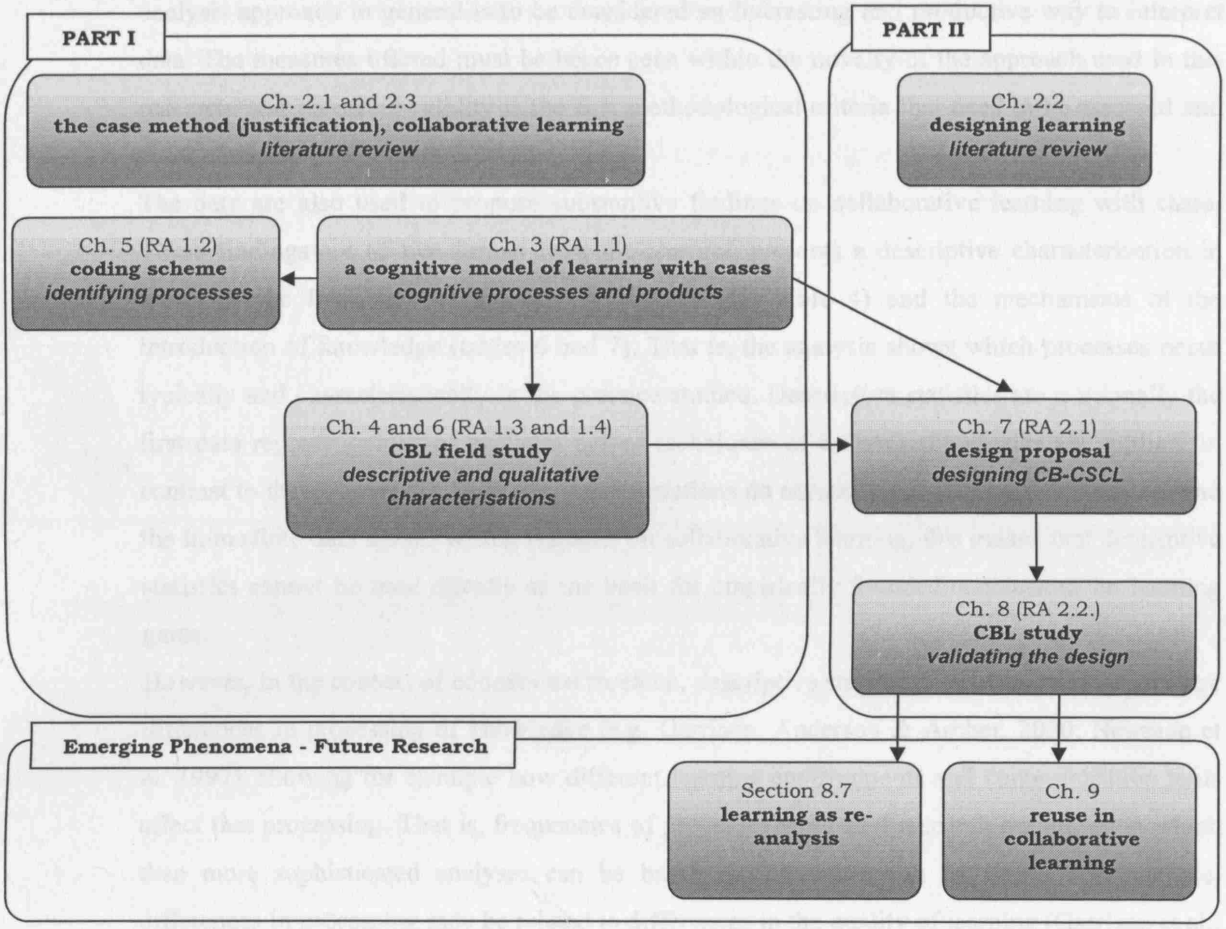

Figure 1. The thesis diagram: the diagram shows the research path, the chapters/sections that answer to the research aims (RA), and the relations between these components of the thesis.

1.8 Research approach and methodology

While the general assumptions on learning of this thesis are commonly made when studying collaborative learning with cases, the more detailed assumptions influencing in particular the way in which the data are interpreted are uncommon. Specifically, the proposal to describe the joint construction of the abstract representation (interpretation, conceptualisation) of the cases, in terms of cognitive processes and mechanisms of the introduction of knowledge is a new way to study collaborative learning with cases. The data function hence especially as testbed of the approach and the analysis tools developed in the thesis.

The ability of the analysis tools to capture the construct defined by the framework is therefore an important methodological criterion. This criterion is generally referred to as construct validity (Murphy, 2004). A high degree of construct validity means that an analysis tool is able to identify most manifestations of the constructs it is designed to identify. It also means that the

analysis approach in general is to be considered an interesting and productive way to interpret data. The measures offered must be hence seen within the novelty of the approach used in this research, and construct validity is the first methodological criteria that need to be assessed and communicated (see section 5.3.3.2).

The data are also used to propose substantive findings on collaborative learning with cases. These findings are of two forms: first, the research presents a descriptive characterisation in terms of the frequency of cognitive processes (see table 4) and the mechanisms of the introduction of knowledge (tables 6 and 7). That is, the analysis shows which processes occur typically and characteristically in the practice studied. Descriptive statistics are a normally the first data representations of analyses before techniques of inferential statistics are applied. In contrast to these, however, frequency representations do normally not allow conclusions beyond the immediate data alone. Within research on collaborative learning, this means that descriptive statistics cannot be used directly as the basis for empirically founded conclusions on learning gains.

However, in the context of educational research, descriptive statistics are often used to compare differences in processing of knowledge (e.g. Garrison, Anderson & Archer, 2000; Newman et al. 1997), showing for example how different learning environments and communication tools affect that processing. That is, frequencies of processes are a first research output, upon which then more sophisticated analyses can be based or inferences can be made. For example, differences in processing may be related to differences in the quality of learning (Garrison et al., 2000), a relation that is made on the basis of models defining which processes are most valuable for learning (e.g. Garrison, 1992). Further, within the view of learning as knowledge building (Scardamalia & Bereiter, 1994), collaborative knowledge construction (e.g. Davies, 2001) or practice (Lave & Wenger, 1991), the study of processing of knowledge as it is evident in learners' communication has become especially important, and is now a core component of learning research. These models of learning refrain from seeing learning as occurring as a one-off occurrence of a process, such as an insight, but rather as the gradual change in competence engendered by social interaction.

The claims about the overall learning outcomes of the discussions must be seen within this research approach. Indeed, with regard to the question of how well students learn, the thesis offers a qualitative characterisation of the outcomes of the discussions. This characterisation is interpretative and relies on a model that relates specific processes to specific cognitive products. That is, by taking the view that learning is the active processing of knowledge and information by a group of learners, identifying how knowledge is constructed and inferring what the products are being constructed by them is a viable research strategy.

The claims being made about the learning outcomes rely on the convergence of all three forms of analyses, with primary significance given to the analysis of conceptual change. This is the primary analysis for making claims about learning outcomes because when it can be shown that during the course of a discussion learners give new interpretations to the cases and/or give new meanings to the specific facts of the cases, it can be said that learning has occurred. Indeed, identifying learning in this way is common in research on collaborative learning and has led to significant advances in the understanding on its mechanisms (e.g. Roschelle, 1995; Chan, Burtis & Bereiter, 1998; Duit et al., 1988). The interpretations of the second and third analyses function here as additional findings of that analysis: they provide additional strength to the claim being made on the basis of the analysis on conceptual change.

The generalisability of the research output is sanctioned by the claims on learning processes and learning products described in chapter 3: they are assumed to represent categories able to function as descriptive categories for educational settings similar to the one analysed in this thesis. However, some restrictions on generalisability apply. For example, current implementations of the case method may use much larger and more complex cases (especially in business education) that are discussed over a period of weeks and even months. In these settings, additional and more detailed learning processes and products may need to be considered. The most incisive restriction on the generalisability on the research output concerns, however, the role and especially frequency of the interventions of a facilitator. In typical case-centred discussions, facilitators do sometimes function similarly to orchestra's directors, reacting to student inputs, directing student intervention, and more in general, attempting to 'produce' a specific learning output (it is no coincidence that sometimes facilitating is described as an art). In the real-world discussions presented here, the facilitator had a minor impact or was not even present most of the time, and her contributions or contributions of the students within exchanges with the facilitator have not been considered. The generalisability of the research output is hence restricted to small-group discussions without substantial interventions of a facilitator.

1.9 Thesis chapters

The thesis has two parts, the first proposing a new conceptualisation of small-group case-centred learning and the second proposing and validating a learning design (see figure 1). The conceptualisation is a new approach to study learning, answers question about processes and mechanisms, and is the basis for characterising learning. The two parts are related: the

evaluation and description of learning in current practices (in part I) is the basis for proposing the improved learning design in part II.

Part I contains the more substantial research of the thesis. That is, extensive research has been carried out to develop a descriptive and qualitative characterisation of a current practice that is representative for collaborative learning with cases. It is argued, in chapter 2, that such a characterisation for the case method does not yet exist in a concise format proposed in this thesis, and that it would provide a valuable addition to more practice-oriented research on the case method.

The study of relies on a framework of learning with cases, presented in chapter 3. The framework has been compiled from a review of research on learning from examples and from problems. It specifies a set of cognitive processes and products that typically occur and are constructed when people learn with cases.

Chapter 4 described the educational context and learning design of the practice.

The novelty of the framework requires also new analytical instruments to identify processes in dialogues. These tools are presented in chapter 5.

Chapter 6 presents the analyses and its results. The discussions are analysed with the instruments presented in chapter 4. The results of the analyses are a frequency representation of cognitive processes and mechanisms of the introduction of knowledge, and well as the identification of conceptual change. The chapter also discusses the learning outcomes and missed learning opportunities. On the basis of these results, the learning design is critically analysed in chapter 7, where also an improved learning design is proposed.

The new learning design is validated with a 2 further studies in chapter 8. It will be shown that the improved learning design promotes conceptual change in 6 out of 12 discussions, presenting a proposal for further improvement of the design. The chapter then discusses specifically the absence of the mechanism of reuse, and proposes a modified design that includes the cuing paradigm. The revised design is successfully tested in a single case study. This study is the basis of a proposal of a model of analogical learning from re-analysis, a model resting on models of analogical learning, but including a mechanism of re-structuring and backwards transfer not addressed in previous research.

Chapter 9 presents and illustrates a phenomenon emerging from the conceptualisations of learning and collaborative learning adopted in this thesis: it discusses one single exchange on a case of medical law, and describes how a novel conceptualisation is constructed by reusing structural knowledge available as an external resource. The generic implications for a model of collaborative learning are discussed.

Chapter 10 presents a summary, conclusions and some more proposals for future work.

Parts of the research reported in this thesis have been published or are under review for publication. The proposal to use multiple matched cases to promote analogical learning has been published as a paper in the proceedings of the International Conference of Concurrent Engineering (Tscholl & Dowell, 2003a). The model of analogical learning from re-analysis has been published as a paper in the European Cognitive Science Conference (Tscholl & Dowell, 2003b). Part of the characterisation of collaborative learning (chapter 6) has been presented as a paper at the Cognitive Science conference (Tscholl & Dowell, 2003c). That characterisation was the basis for a further study (not reported in this thesis) investigating the effect of different media on learning (Tscholl, McCarthy & Scholl, 2005). Chapter 9 has been submitted to the Journal of the Learning Sciences for peer review. The proposal to adopt a cognitive science perspective to study collaborative learning has been published as a paper at the 2008 International Conference of the Learning Sciences. The framework to identify conceptual change in case-centred discussion has been published as a paper at the 30th Annual Meeting of the Cognitive Science Conference.

Chapter 2

Background:

the case method, collaborative learning, and the idea of 'learning design'

2.1 Introduction

This chapter presents a survey and analysis of prior work on which this thesis draws, and with which it sometimes stands in contrast. The sections introduce essential notions of collaborative learning and learning design, and also clarify the positions of the thesis within the current research landscape.

The first section introduces the case method at large: what it is and how it is applied in practice. The focus of this first section is on current views on the method and how it is conceptualised. The views of practitioners using the case method on what students learn is presented as well views of learning theories on the case method. This section gives a major impetus and rationale to part 1 of the thesis: it will be argued that very little use of learning theories is made when describing the mechanisms of learning with cases, and what is learned with the case method.

The thesis, by presenting a conceptualisation of the central component of the case method (the small-group discussions) attempts to contribute to the understanding of it.

The next section introduces the core issues of research on collaborative learning. It will be shown that several conflicting and complimentary views of collaborative learning exist. The section introduces the 'social' view on collaborative learning, and its resulting research approach that focuses on collaboration-specific mechanisms. The section introduces also the 'individualistic' view that has offered some explanations for the effectiveness of collaborations, but is grounded in the more traditional symbolic view of cognition. Extensive discussions on the role of interaction and the notion of jointness are presented in order to clarify the different views on collaborative learning.

The last section introduces the notion of 'learning design' and presents the thesis' use of this notion. The last subsections introduce the notion of 'design targets' and presents research that designed learning by specifying these components of the learning design.

2.2 The case method

2.2.1 Introduction

This section presents the case method. The purpose of the section is, besides giving a general introduction to the concept of case and to the traditional uses of cases in education, to show that questions about the learning mechanisms occurring when learners engage with cases have only been insufficiently answered. Descriptions of the case method are, as Burgoyne & Mumford (2001) point out confined to how to implement it, rather than explain why and how it works. An answer to these questions is rendered difficult by the discordance between practitioners about what is learned, and the absence of thorough research on that issue.

This section is central in justifying the questions asked in the thesis: the absence of theorisation of the case method and the lack of answers about how it works, noted by Mumford as recently as 2005, gives the major impetus to part 1 of this thesis. That part will indeed propose answers to these questions, and attempt to do so by re-conceptualising learning with cases within a cognitive framework (chapter 3).

The section is divided into 4 subsections. In the first subsection, the concept of case is introduced and its use in an educational context described. The two main uses of cases, for decision-making and analysis, will also be introduced. The second subsection describes general appreciations and more specific investigations of the educational effectiveness of the case method. This section will also summarise studies on the type of knowledge acquired through

case-centred learning. The third section introduces shortly theories of learning employed to provide a descriptive account of the case method. Based on the claims espoused in subsection 2 and 3, the need to provide answers about what is learned with the case method and how learning works is justified in the last subsection.

2.2.2 The case method: description and uses

The case method is an established educational method, used especially in higher and continuing education. Though in principle the method is employable in many domains, it is generally used in business, management, law, and recently also in medicine. The case method is, in short, the educational method where students learn by studying with cases. The description and characterisation of the method will start with a description on the concept of case.

The definition of 'case' owes much to its history of use in education: cases were originally narrative reports, usually first-hand accounts, of managers and other business practitioners about situations that organisations (such as companies) have been involved. A case would describe how a situation arose out of long- or short-term goals, of a plan or of circumstances, and how these situations were addressed and solved. Cases were, and still are, presented as narratives, i.e. relatively faithful and 'raw' accounts of events. A commonly accepted general description is Barnes, Christensen & Hansen's (1994): cases are "a selection of reality, a slice of life, stories". Cases differ in length, from about 1000 words to many pages, and they also differ in presentation format: though the most common form of a case presentation is written text, occasionally though, the written description is augmented by material presented in multimedia formats.

There exist several types of cases. Heath (1998) categorises them into 6 classes: decision cases, incident cases, exercise cases, complex cases, situation cases and background cases. These classes were identified on the basis of what 'message' a case conveys, which main task is assigned to the students and what background knowledge should be employed in the study of the case. For example, an incident case gives a short account of a one-time event and requires students to identify the 'message', its 'point'. When studying a background case, students are normally required to apply a specific conceptual or analytical framework to the case. As will be discussed later, this variety, in 'message', task and background knowledge renders a unique specification of what knowledge is acquired difficult.

Despite the variety of cases, the classic function of the case method is to analyse the case, and suggest and justify and interpretation and/or decision (Christensen, Garvin & Sweet, 1991).

Volpe (2002) distinguishes, in line with this classical distinction, between the following two uses of case.

The first way is to use the case study as a support and an illustration in lectures and seminars. For example, in the lecture a tutor may explain how the case illustrates typical dilemmas or issues that policy-makers, public or private managers face and the principles that can be used to help them reach a reasonable decision. In seminars, short cases can be discussed to show the application of theory, stimulate analysis and induce evaluation. Here, cases are employed to stimulate analysis.

The second way of using case studies is to challenge the students to grapple with a decision-maker's dilemma, formulate a strategy and come to a plenary discussion prepared to explain and defend their recommendations. In this approach the instructor either does not lecture or conducts a limited number of lectures that are complemented by the analysis of longer and more complex case studies. The role of the tutor is to moderate a classroom discussion among the students in which the students compare their different approaches, decisions or solution proposals, i.e. she primarily facilitates the discussion.

When cases include a description of a decision that description may be given to students concomitantly with the situation description or only after the students have proposed their own decisions. For example, students discussing a case describing a company's critical situation that arose out of certain circumstances may not be presented the real remedy employed by the company until after they have analyzed the situation and proposed their own remedy. Such a phased presentation of a case permits students to compare their own solution to the one adopted by the company (i.e. by real managers) and gives students realistic feedback on their abilities to analyze and act in a complex situation.

A last important characteristic of the case method is that it is mostly collaborative. Students may prepare for a learning session on their own by, for example, studying pertinent background material, but the essential tasks, such as decision-making or analysis, are carried out as group activities. The collaborative setting is, according to most practitioners, essential because it increases the number of different viewpoints available to the individual student, and increases the complexity of the task faced by the students. The collaborative setting augments the opportunity for integration of knowledge and promotes analysis. This aspect of the case method is captured by the concepts of 'producing joint solutions' and 'integrating knowledge', both core issues of collaborative learning research (see section 2.3). As will be described in the next section, the acquisition of analytical skills, and the ability to "handle complexity" are amongst the most valued improvements deriving from studying with the case method.

With the emphasis on group learning, the group size becomes an important factor for the success of the case method. Burgoyne & Mumford (2001) report that sometimes groups consist of 80 students, though such numbers are probably only effective in plenary sessions. The much more important small-group sessions consist of 3 to 10 students. At least two factors are influenced by the group size: in large groups (6 – 10) at least some students tend to hide (Ewing, 1990) and giving voice to all of them is more difficult. However, small groups (3 – 5 students) are lacking variety in viewpoints (Hill, Bruns & Ragan, 1996), and in addition require more tutoring personnel.

2.2.3 The case method: what is learned

In recent years the case method has seen an increase in use and gained wider acceptance. Some schools, especially business and management schools, use the method exclusively, though generally only in the last years of undergraduate, or in graduate and professional education. The rationale for using the method at that stage lies in the assumption that the case method is especially effective when students possess some substantive domain knowledge. Once students have acquired substantive knowledge - in a traditional tutor-focussed setting – studying cases gives them the opportunity to apply that knowledge to concrete situations. Some aspects that the method shares with other methods, most of all problem-based learning, are gaining in general more prominence at all levels of education. The case method follows and to a degree is also a forerunner of recent trends in education towards more student-centred, active learning, self-directed, and collaborative learning. The factors for this trend are social and economical but also pedagogical. The increased use of the case method cannot however be traced to thorough assessments of its educational effectiveness as indeed opinions about the general effectives and specific learning gains vary widely. This is discussed now.

Tutors employing the method differ in their pedagogical expectations: some expect students to learn very specific skills, while others expect no more (or no less) than "the acquisition of abilities to exploit future problem solving experiences" (cf. Maufette-Leenders, Erskine, & Leenders, 1997). Differences in the formal or informal assessment on what kind of knowledge is actually acquired by students are also substantial: they vary from relatively underspecified meta-knowledge, such as 'a sense of complexity of real-world problems' (Ewing, 1990), to knowledge about how to make decisions, solve problems, argue and discuss. Also various skills are deemed to be learned, such as analytical skills, reasoning skills or skills for diagnosis (cf. Burgoyne & Mumford, 2001). Scant appreciation is given to the acquisition of conceptual knowledge.

Several reports or studies on the case method agree that knowledge about how to do things (skills and procedures) is the primary form of knowledge acquired. Burgoyne & Mumford (2001) review the literature on the case method selecting accounts on what is learned. A summary of their findings is clear about the preponderance of skills. They give the following summary: students acquire 'skills of analytical – reasoning, of sifting and evaluating data', of 'questioning', 'diagnosing', 'problem solving', and 'skills in communicating and influencing others'. Also less specific skills are reported to be learning: 'an improved capacity to be objective by absorbing other people's viewpoints', 'group skills – sensitivity and awareness of others', 'ability to generalising from the specific', 'capacity to integrate theory into own practice', 'ability to make decision', 'skills in winning arguments'. Barnes, Christensen & Hansen (1994) confirm this view and assigns learning of factual knowledge a minor role: "the classroom should be for insightful learning, not basic knowledge gathering": analysis, reasoning and diagnosis skills, and communication skills are, according to the author, the most significant knowledge acquired through the case method.

Whether reasoning skills are indeed acquired through the method is however questioned by other educators. For example, Ewing (1990) and Barnes, Christensen & Hansen (1994), the most outspoken promoters of the case method at Harvard Business School, argue that the acquisition of specific skills is neither the aim nor the outcome of learning with the case method. Rather, they emphasise rather under-defined "approaches to solve problems and make decisions" are the most valuable learning outcomes: students "gain familiarity with generic features of situations that they will likely encounter in the real world", features such as "that there is no easy answer – complexity is ever present" and "that decisions must be made on the best information available". They also stress that "the students develop an idiosyncratic framework to approach, understand and deal with problems" and "learn how to express oneself and perhaps to persuade others to ones' point of view". A more radical view is held by Jennings (1996) who dismisses the general assumption that learning of analytic and reasoning skills is promoted by the case method, and restricts its usefulness to developing communication and interpersonal skills.

The acquisition of social and communication skills is accepted by many practitioners. For example, students learn how to work in teams and how to make decisions in teams. The acquisition of these skills is considered particularly significant because they are learned best in practice, and are essential skills for some professionals. In a sense, a case-centred discussion is an artificial, yet still somewhat realistic, environment resembling boardroom meetings or other settings where social and communication skills can be developed safely. It should be pointed

out that one of the critiques of the case method targets this artificiality: while students may learn how to analyse a situation or make decisions in collaboration, their proposal will not be implemented in reality, thus reducing realism of the situation. As Argyris (1980) comments on this problem: "the problem was not that the students did not learn new ideas, [...] but that they rarely used them". The lack of realism inhibits, according to Argyris, important learning processes (see section 2.2.4).

A form of learning that is sometimes mentioned in the assessment of the efficacy of the case method is 'learning how to learn'. Some authors have attributed it an efficacy in preparing future professionals in learning from their experiences (Erskine, 1998), that is, to acquire the necessary skills to address difficult situations and analyse discrepancies between intention and outcomes that will always occur in their activities. This assumption remains, though, at a theoretical level, as no empirical studies have been carried out to assess the differences of 'learning to learn' ability in professionals that have or have not been taught through the case method.

Markedly absent in the appreciation of the case method is, besides conceptual and domain-specific substantive knowledge, episodic knowledge, i.e. the memorisation of the cases themselves that could be reused to solve similar cases. It is hypothesised here that this absence is due to a lack of appreciation of cognitive theories of learning to model case-centred learning. This will be discussed in the conclusion section.

2.2.3.1 Insight learning

Educators employing the case method promote a special form of learning actively: insight learning. This phenomenon is integrated into the tutoring practices of the Harvard case method, where tutors strive to direct the dynamics of a discussion towards its peak: when the students understand the 'point', the 'story' of a case. For example, tutors may point out issues or items in a case that 'make the students wonder', that generate real puzzlement, a state of mind that, for it needs to be resolved, might lead to an insight.

People experience insight when seemingly disparate elements of a problem become suddenly related and the problem 'makes sense'. Traditionally, insight is correlated with the abstraction of a schema: in fact, it is a schema, an abstract description of the problem that serves as the knowledge that relates problem elements. The schema can serve as a solution, as a schema is generally a typification of a problem. Insight learning can however also occur when a framework is applied to a concrete situation, such as indeed a case.

2.2.4 Views on the case method

It is maybe not too much to say that the case method is one of the most celebrated methods in education. Educators continue to praise its effectiveness and papers and books on how to use it continue to be published. Also, as described above, its employment in education is increasing, both in existing and in new domains.

However, Burgoyne & Mumford (2001), in a thorough critical review on the case method that surveyed the literature in an attempt to find out why and how (in terms of learning theories) the case method works concluded that there have been as yet no efforts to answer these questions. More in general, the case method remains a practitioner's realm, i.e. discussions on why and how the case method works are "pragmatic and a-theoretical". Indeed, the authors argue that "central to the case method is scepticism about basing management and organisational practice on any straightforward application of theoretical generalisations" (pg. 5). It appears that educators using the case method believe that skills and other knowledge acquired in a realistic context and reported as realistically as possible in a case cannot be subjected to theoretical scrutiny. Imparting this knowledge is seen as an 'art', as it were.

Some theories and models of learning have been used to describe the case method, though they remained at a superficial level of description (Mumford, 2005). The inspiration on the importance of 'acquiring knowledge in a realistic context' is generally attributed to J. Dewey. Dewey's observations on learning inspired an educational mode that promotes active learning, self-directed learning and student-centred learning, as opposed to traditional instructional tutoring. An important aspect of his philosophy is to have challenged the 'information transmission' model of tutoring, and proposed instead a model whose centre is the person as a whole. Dewey's teachings are partially implemented in the case method. For example, advocates of Harvard's case method claim that education should be aimed at "quality of mind (curiosity, judgment, wisdom), qualities of person (character, sensitivity, integrity, responsibility) and the ability to apply general concepts of knowledge to specific situations" (Barnes, Christensen, Hansen, 1994).

Dewey's view was translated into practices that emphasise educational tasks promoting problem solving and abstraction from a concrete problem. In this, they partially simulate what is known as 'experiential learning', i.e. learning when solving problems in the real world. A major support for the efficacy of this form of learning is the observation that expertise is exclusively acquired from experiences with real-world problems.

Kolb's (1984) model of 'experiential learning', described as a learning cycle, has also been relied upon to provide some formalisation of the case method. The learning cycle consists of four stages (*active experimentation*, *concrete experience*, *reflective observation* and *abstract*

conceptualisations), and captures the dynamic of learning by engaging with real world problems. In its emphasis on the realism in learning, and its description of the acquisition of relatively stable and abstract knowledge structure, Kolb's model has some attractiveness as the basis for describing how learning with cases works. However, the model has only been used to provide a superficial descriptive account about the main learning dynamic of learning with cases, without major effort being devoted on verifying the applicability of the model to the detailed learning processes.

Argyris' analysed case-centred learning sessions and criticised the method for the absence of double-loop learning. Learning, according to Argyris, occurs in two forms, operationalisation of existing action strategies and questioning of governing variables (Argyris, 1980). Reflection upon and analysis of errors (errors are mismatches between intentions and outcomes) are the most proficient learning activities, especially when they are directed at governing variables, such as core company policies (double-loop learning). Errors occur when there's a discrepancy between 'theories in use' (mental maps that people implicitly use to make decisions and act) and 'espoused theories' (theories that people think they are using). According to Argyris, the inability to implement decisions (to act) prevents students to discover the discrepancy between 'theories in use' and 'espoused theories'. Despite the promotion of reflection and analysis, the 'safety' of the environment hinders students to discover variables that govern the behaviour of institutions. The result of his analysis may be understood as an implicit critique on the effectiveness of the case method to impart knowledge other than the skills described above.

2.2.5 Summary

The picture that emerges from a review of the research that has attempted to explain how and why the case method works is the following: first, not much research of this kind exists. Mumford (2005) argues that still little use is made of learning theories to explain the case method, and contends that the absence of a theorisation disallows a comparison between the case method and other methods. And second, that research aiming at answering these questions will have to contend with the fact that there is wide disagreement even on what is learned with the case method. That is, while most practitioners agree that the method is effective, they do so by citing different learning improvements, that range from well-defined skills to the rather lesser defined 'personal qualities'.

One of the central issues that remain unexplored, and have already been identified by Argyris (1980), is the extent to which the case method brings reality to the learner and permits her to practice real action (as described above in detail, Argyris conceptualises this problem in terms

of the absence of double-loop learning). Claims about the acquisition of skills, especially argumentation, debating, reasoning and analysis skills, are, given that it is exactly these skills that are practiced with the case method, sensible. However, the emphasis practitioners of the case method place on insight learning and the absence of any claims about the acquisition of substantive and domain-specific conceptual knowledge are inconsistent: insight learning is one of the core mechanisms of higher-order cognition, and is based on and affects conceptual knowledge. It appears hence that cases are also useful for reorganising existing conceptual knowledge, i.e. that the realism of cases does not so much permit 'real action', but rather that engagement with a case promotes those kind of learning processes that affect how we interpret the real world, i.e. conceptual knowledge.

This is one of the core contentions of this thesis, and the first part of this thesis should be seen as an attempt to formulate a learning theory of the case method, restricted though this attempt is to a small range of phenomena of learning. The thesis proposes hence to advance towards an explanation of the effectiveness of the case method by re-conceptualising learning in terms of a set of learning mechanisms of higher-order cognition. These mechanisms, presented as a framework to study learning from cases, are described in chapter 3.

2.3 Current issues and notions on collaborative learning

2.3.1 Introduction

As has been described in chapter 1, learning in groups can be studied from several perspectives, one of them what could be called the social perspective, and another being the knowledge perspective. Integrations of these perspectives have been advanced by, for example, Pea (1993) who described the core question of collaborative learning research as: "how do interactions [the social level] result in a modification of the learners' conceptual structure [the knowledge level]"?

This thesis assumes that learning in collaboration can be studied in terms of processing of knowledge and information that occurs in the social plane without considering that special social mechanisms need to be taken into account. For example, it is assumed that to construct new knowledge, a student uses knowledge introduced earlier into the discussion by a peer or relies on her own knowledge (the hypothesis of equivalent access; Perkins, 1993). A discussion is seen, in this thesis, as an externalisation of individual cognitive processes (the person-plus view; Perkins 1993).

The sections are organised as follows. The first section presents current definitions of collaborative learning, and then describes the social perspective. That view is then clarified through an example that is discussed also from the perspective of individual cognition. It will be argued that learning in collaboration can be analysed in terms of collaboration-specific mechanisms or mechanisms of individual learning. Then, the position of a strict view of collaboration (that assumes that knowledge is constructed truly jointly) is described by discussing the notion of jointness. That position is then contrasted with the individualistic position on collaborative learning that emphasises the role of individual learning in groups.

2.3.2 Introduction to and definitions of collaborative learning

Research on collaborative learning has become one of the main foci of the learning research community. Though in some form or another people have often or even normally learned collaboratively, it is only recently that the role of collaboration of learning has been researched extensively.

The appraisal of this form of learning may be traced to pedagogical and psychological theories that have countered several of the core tenets of earlier models of learning, in particular of traditional tutor-led instruction. Several theorists have proposed, for example, that knowledge is jointly constructed in social situations rather than transmitted from a tutor to a student. The assumption that people carry out tasks in isolation has also received criticism. Proponents of the view of Distributed Cognition (e.g. Salomon, 1993) pointed out that knowledge and tasks are distributed and that a dependency exists between people and people, and people and the environment.

There is as yet no widely accepted definition of what constitutes collaborative learning, and indeed the differences of definitions are extensive (cf. Dillenbourg et al., 1999). A simple definition considers collaborative those learning situations where at least two people engage in educational activities, share the learning resources or the need to produce a shared educational output (such as a coursework). Stricter definitions include the requirement that the activity is indeed and demonstrably collaborative, i.e. that activities are carried out jointly. This may include the requirement that the educational 'product' is the integration of the participating individuals' knowledge. The jointness of learning is a crucial criterion here, and it will be discussed more in detail later.

More or less strict definitions of collaboration may be made on methodological not ontological grounds (cf. Stahl, 2003). A strict definition may be used in order to define clearly the

phenomena of interest of the discipline, and provide a guideline to the appropriate methodology. This is necessary to position the research within the general area of research on learning. However, ontological assumptions do play a role in the view of what is collaborative learning. For pedagogies asserting that new knowledge results generally from social negotiation, learning is collaborative in essence: learning that is not done collaboratively is not learning, because all knowledge and meaning is constructed socially.

A discussion on the ontological differences of collaborative learning is beyond the scope of this thesis, though different views on collaborative learning will be discussed not only on methodological grounds. In this thesis, a broad distinction is made between the 'social' view of collaborative learning and the 'individual' view. The following sections give a short overview of theories of learning and the location of the two competing views on collaborative learning. Then, the difference is illustrated through an example.

2.3.3 Meanings of learning

There are several meanings of learning that mostly exist in parallel, but are sometimes in contrast. Learning may be seen as occurring throughout one's lifetime, especially in situation where tasks are carried out. This view equates learning with the acquisition of professional skills within a community of practitioners (cf. Wenger, 1998). It also assumes that there exists a strong overlap between learning and collaborative learning, because learning occurs in a social setting by participating in professional practices. Another view of learning, that may be termed the educational view, views learning as occurring in special situations with particular tasks, material and tutor support. An important characteristic is this view is the focus on activities conductive for learning, less so on cognitive mechanisms of learning. This is the focus of the third approach, termed here the individual-mentalistic approach. It is mostly represented by academic laboratory-based research, at the expense of conceptualisations and research of high ecological value. Behaviourism and cognitivism are major representatives of this approach.

2.3.3.1 Social learning

That learning occurs in a social environment is accepted by most pedagogical theories. However, there exists wide disagreement on the role and the effect of the social interaction. One major distinction in this regard is between the following two views: one view, the classical cognitive science view, sees the social setting as being only a promoter of learning – intended as the acquisition of abstract knowledge structures – in the mind of the individual, and assume that

what is learned is decontextualised knowledge that is 'taken away for further use' by the individual (cf. Sfard, 1998). The contrasting view assumes that learning is in the activity of the learner, i.e. that, for example, it is interactions with people and tools (including conceptual tools) that are learned (e.g. Brown, Collins & Duguid, 1989). In this latter view, behaviour is always contextualised, i.e. tied in some form to the environment within which the activities take place. Social constructivism, for example, assumes that learning is becoming knowledgeable of using cultural and social tools (including language) that hence education aims to promote the gradual appropriations of these tools.

A maybe paradigmatic conception of this view is Lave & Wenger's (1991) 'community of practice'. The authors describe learning as a situated phenomenon where people, instead of acquiring formal knowledge, become able to use their environment (including their social environment) to accomplish tasks. Learning is the "gradual appropriation of culturally and socially defined tools". In this view, there is therefore, in terms of collaborative practices, a relationship between models of problem solving and models of learning: learning occurs by participating in activities aimed at solving real-world problems.

Cognitive constructivism, in contrast, assumes that learning occurs socially, but that it promotes the acquisition of formal knowledge in the individual. The role and effect of interaction is therefore a core question in collaborative learning research, and also a central criterion to locate the thesis within learning research.

In the next section, the focus of research of the social view is presented by discussing a specific example that highlights the emphasis that the social view places on interactions.

2.3.4 Collaborative learning: the research focus of the 'social' view

The currently most prominent view about what the focus of collaborative learning research should be interprets learning in groups as something beyond the individual. Dillenbourg (1996) describes collaborative learning as being greater than the parts that compose it: the processes that individuals composing a group possess and apply to the object of study do not overlap with the mechanisms of learning that occur in the group. For example, in groups, people argue about topics, and negotiate how to interpret problems or solve problems. Argumentation and negotiation are collaboration-specific mechanisms of learning, and most research focuses on these mechanisms. They answer the questions: how do people argue, how do they negotiate, how an interaction is sustained, what are good forms of argumentation, etc. These may be called the social mechanisms of learning.

There are views that contrast with this social view, or incorporate both the social and the individual, and nevertheless consider collaboration to be essential for learning. For example, Piaget's theory of learning recognized the importance of social interactions (cf. Piaget, 1977), but maintains nevertheless that learning is the modification of abstract knowledge structures possessed by the individual. The social interaction is seen in this view as a *promoter* of individual learning, and learning itself is the modification and refinement of existing abstract and decontextualised knowledge. In a similar vein, learning occurring through the mechanisms of explanation and self-explanation (Chi et al., 1994) is internal, being prompted however by the social setting (e.g. the presence of others promotes explanations).

I will now illustrate the differences between the views, in order to illustrate the assumption taken in this thesis. Dillenbourg (1996) cites an exchange between two students learning how to program, and discusses a particular sequence when they negotiate the application of a rule. That negotiation leads to the solution of the problem, but especially also to what could be called the possession of new knowledge: each of the students acquires, as a result of the discussion, new valuable knowledge about how and when to apply the rule. The difference between the views is best illustrated by their answers about the question: how did that acquisition come about? It is a result of the negotiation, to be sure. That is, each of the students brought their own and different knowledge into the discussion, and selected the one that seemed to both to be the right one, or produced a joint solution that accommodated both (incomplete) views (see section 2.3.6). Without the others' knowledge, neither of the students would have been able to solve the problem. Negotiation is therefore essential for learning. And, as several researchers have claimed (e.g. Resnick, 1988), since learning is seldom *not collaborative* (i.e. people rarely learn on their own), learning research should really focus on these mechanisms. The alternative view would point out that, whatever the social situation, what really has occurred is that a traditional cognitive process, the mechanism of rule instantiation, has ultimately led to the acquisition of knowledge. That is, the negotiation over how and when to apply a rule led to nothing more or less than what we know about how the mind acquires knowledge about how and when to apply rules to a situation. In a sense, if one student was to work on this problem on her own, and was also to hold the same knowledge in her mind that in the two-student situation was held by each of the students (this is certainly an important and contentious assumption), she may have selected the right one (or even abstracted over both), and the same cognitive process of rule instantiation would have occurred. One of the earliest explanations borrowed from cognitive psychology to explain the effectiveness of collaborative learning, the sharing of the cognitive load (Sweller, 1988), would point out that the student working on her own had less a chance of solving the problem and learning because processing all knowledge would have been computationally difficult. But this student-working-on-her-own example should illustrate the

point: that learning in the sense of acquiring new knowledge resulted from a negotiation that is a mechanism that helped both students to learn.

What this description and discussion of Dillenbourg's example did is to illustrate two different approaches to study collaborative learning. The contrast may be seen as being about two different objects of study of a collaborative situation: the social view would focus on the social mechanisms occurring (such as argumentation, negotiation and interaction), while the individual view would focus on processes of knowledge elaboration, knowledge refinement, knowledge construction, etc. That view considers what Baker (1994) calls the knowledge level of collaborative situations: it answers the questions related to the knowledge used, the knowledge transformed, and the knowledge acquired. The social view is interested in how people negotiate, how they argue, how they interact, not what the argumentation is about, what they negotiate, in order to derive a conclusion about what they learned.

2.3.5 The role of interactions in learning

Having identified the research focus on interactions as one of the defining aspects of the social view, the role of interactions and how the individual view interprets them will be discussed now.

As mentioned above, while the value of interactions for learning is widely accepted, there exists disagreement on the effect of interactions. For cognitive constructivism, for example, interactions are catalysts for individual cognitive change. According to this theory, the learner actively constructs knowledge as she interacts with the environment. Of particular importance are interactions with peers. These interactions may lead to cognitive conflicts and can be solved through argumentation and debate. In this view, the interaction functions as an implicit test of the usefulness of existing knowledge to interpret or explain the world, or solve problems in it. If an interaction is unsuccessful, abstract knowledge guiding the interaction is modified (accommodation or assimilation), and this is deemed to be learning.

It is important to point out that this model of learning focuses entirely on what goes on in the mind of the individual: though the modification of knowledge occurs in a social interaction, it is not assumed that knowledge of other people participating in the interaction is appropriated by the learner. This is a crucial distinction with social and cultural constructivism, where the interaction with a more able peer leads to the gradual appropriation of the more able peer's knowledge. The following example from Vygotsky (1978) illustrates this form of learning:

> "We call the internal reconstruction of an external operation internalisation. A good example of this process may be found in the development of pointing. Initially, this

> gesture is nothing more than an unsuccessful attempt to grasp something, a movement aimed at a certain object which designates forthcoming activity. . . . When the mother comes to the child's aid and realizes this movement indicates something, the situation changes fundamentally. Pointing becomes a gesture for others. The child's unsuccessful attempt engenders a reaction not from the object he seeks but from another person. Consequently, the primary meaning of that unsuccessful grasping movement is established by others . . . The grasping movement changes to the act of pointing. As a result of this change, the movement itself is then physically simplified, and what results is the form of pointing that we may call a true gesture."

This example illustrates, according to a social constructivist view, how a child acquires knowledge: she uses her existing knowledge to interact with the environment, and when this attempt fails, the meaning of her original activity is modified. This knowledge is constructed mutually: the child appropriates the meaning that her mother has assigned to the gesture, and occurs because there is understanding of the child's intention.

2.3.6 Jointness

Negotiation of meaning and shared meaning-making are the core mechanisms of learning of those theories that reject the assumption that interactions are merely promoters of individual learning. These concepts can be discussed in terms of jointness: negotiation of meaning requires that tasks are carried out jointly and that the product of the interaction is joint. Joint product means here that the resulting knowledge is different from the knowledge held individually and results from an integration of this knowledge.

Roschelle's (1992) description may best represent this conception. In his study, dyads are working to solve a physics problem that requires them to produce an abstract representation of a concrete situation. This abstract representation should embody physics principles that are operating in the concrete situation. In particular, the conceptions of velocity and acceleration were to be elaborated (see figure 2).

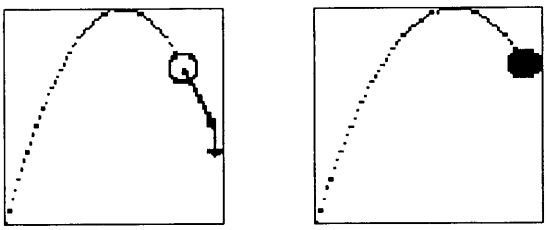

Figure 2: problem situation in Roschelle (1992). The left picture is a snapshot of the simulation of a Newtonian mircoworld; the two arrows represent acceleration and velocity. The right picture is a real-world situation. The students' task is to manipulate the arrows in order to reproduce the trajectory of the object (ball) of the simulation.

The successful solutions resulted from a cooperatively constructed understanding of acceleration. This understanding emerges from the "coordinated synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Teasley & Roschelle, 1995). The problem was hence solved through a social mechanism (creating and maintaining a shared conception) without either of the students bringing the full and correct solution into the discussion. It is instead generated by integrating incomplete individual knowledge. The following dialogue (figure 3) illustrates knowledge integration:

D: But what I don't understand is how the lengthening, the positioning of the arrow...

C: Ooh you know what I think it is? It's like the line. Fat arrow is the line where it pulls that down. Like see how that makes this dotted line. That was the black arrow. It pulls it.

Figure 3: dialogue excerpt (from Roschelle, 1992) illustrating knowledge integration and joint production of solution (C and D are students)

In the interpretation of the authors, the solution proposed by C wouldn't be possible without D's utterance. This utterance is a source of knowledge for C. Indeed, the contiguity of 'lengthening' and 'positioning' suggests a relation between the two diagram features, a relation that is then specified in C's utterance. The solution (new knowledge) is truly a joint product; and the interdependence of the students here is based on they being providers of knowledge, even if this knowledge is partial, incomplete, maybe incorrect, a question or intended to suggest doubts.

Knowledge integration[1] is a mechanism that may be useful to explain how peers are able to produce knowledge that is qualitatively different from individually held knowledge. By

1 In this discussion, knowledge integration is understood as integration of knowledge from different individuals. The notion of knowledge integration is also used to described learning in an individual (e.g. Davies, 2003)

'qualitatively different' is normally meant 'more abstract'. In the cited study's case, the jointly constructed knowledge is of qualitative nature: it captures structural relations invisible to a novice, and approximates the problem descriptions of experts (for the definition of 'structural knowledge' see section 3.2.2). In a sense, the result of the problem solving session can justifiably called successful learning because the acquired knowledge, evident in the problem description, is conspicuous in its character to 'look beyond' the surface information given (Chi, Feltovich & Glaser, 1981).

That groups produce knowledge that is different from individually produced knowledge is a well-evident phenomenon. For example, problem description of dyads and triads typically go beyond abstractions of the most able member (Schwartz, 1995). Further, there is evidence that groups are able to solve problems that the individuals composing it fail to do (Schwarz, Neuman & Biezuner, 2000). This supports the general view that peer interaction is the key to learning.

However, the attribution of this effect to knowledge integration can be disputed on several grounds. A first argument centres on the requirement that in order to be integrated, knowledge needs to be expressed. Clear evidence confirming the expression of knowledge in utterances prior to knowledge integration is yet unavailable, but a more general argument can be made that knowledge is changed or acquired in situation where the interlocutor is entirely devoid of domain knowledge or even any kind of semantic knowledge. Indeed, it could be argued that improved understanding can emerge in dialogues where responses or, more in general, interactions are guided only by a syntax-based elaboration of utterances (Weizenbaum, 1966). It is this effect of 'semantically blind' tutors that is guiding currently the research on AI programs that interact 'intelligently' with students. There may be, in essence, meaning making without it being joint.

A second argument against the 'knowledge integration view' is based on the necessary character of joint construction, specifically on the necessity of agreement. Indeed, Roschelle (1992), for example, characterises the process of collaborative learning as a search of convergence among group members. However, as Miyake & Shirouzu (2002) pointed out, evidence of convergence is unconvincing. It is possible that one student only acquires a new understanding, and the peer merely adopts this interpretation, i.e. that shared understanding can be acquired without integration of individual conceptions. Criticism recently focusing on the notion of common ground is in parallel to the one described here, and offers additional support. Common ground is a concept that denotes agreement, normally implicit, between learners and is necessary to achieve shared understanding (Clark and Brennan, 1991). Agreements can be had on task or role distribution, but also, and relevant for this discussion, on the interpretation of the learning material, or the problem or case. Though one may argue that complete agreement is unrealistic,

it is normally accepted that high agreement between learners means that they have achieved common ground, which is necessary for joint knowledge construction. Content analyses have shown, however, that substantial learning can occur without their having been achieved common ground (Koschmann et al., 2001). Indeed, it seems to be the norm that in situations that have been paradigmatic for the social-constructionist view, namely cooperation in a shared task among peers with different levels of competence, common ground is not achieved. As Koschmann & LeBaron's (2003) OT analysis shows, ambiguous words and gestures meant to increase the sharedness of reference or interpretation remained unambiguated, what did however not impair the task execution.

It seems, therefore and as a result of these argumentations and evidence, that the importance of jointness and sharedness for collaboration must be re-dimensioned, and what could be called the 'individualistic-mentalistic' view given more prominence. This view is presented now.

2.3.7 The 'individualistic' position on collaborative learning

The theory best representing this view is the socio – constructivist theory of learning. It assumes, centrally, that learning occurs through interactions with the social and material environment, and that these interactions are catalysis for individual learning (cf. Dillenbourg et al., 1996). Piaget's (1977) view of learning is normally cited as the basis for this theory. Piaget assumed that knowledge is represented in mental structures characterized as non-atomic cohesive representations that are the basis for recognition of objects and events, and guide interactions with them. These representations (schemas) are the locus of learning: learning is a modification of schemas occurring when a schema accommodates to something external or incorporates something external (assimilation). As described above, interactions serve as implicit tests of the usefulness of schemas in interpreting the world, and failures to do so lead to a modification of a schema.

The influence of the socio – constructivist view will be outlined further later; for setting out the concept of learning adopted in this thesis, it is important to emphasise that this view, at least in Piaget's original formulation, makes a clear distinction between the environment and internal, mental representations. This emphasis becomes significant if alternatives, such as the distributed or situated cognition view, are considered, where the environment is deemed doted with intelligence (Hutchins, 1995), and internal representations are not considered as focus of research. This alternative approach emphasises the role of the external environment in cognition: people use the environment to carry out tasks (the person-plus view; Perkins, 1993), and modify their environment to help them carrying out tasks (Kirsh, 1995). The notion of

internal mental representation does lose, with this definition of cognition and learning, its sense because such representations do need to be assumed to be abstract and relatively general to be accommodating. Cognition tied to the environment is, instead, specific and concrete.

Several research strands on collaborative learning have adopted the individualistic position. Two of the most important ones are described now.

A set of studies, mostly authored or co-authored by M. Chi, centres on the effect of explanation and self-explanation on learning (Chi & Bassok, 1989; Chi et al., 1989) that are characteristic for utterances in collaborative learning situations. These studies represent the maybe strongest marriage between traditional cognitive psychology and collaborative learning research. This includes the use of traditional methodology, i.e. learning is assessed through pre- and post-session tests. The main question investigated is one emerging from the observation that in groups with disparities in competence all group members profit from collaborative learning (cf. Dillenbourg et al., 1996). This observation, clearly refuting the simplistic information-transfer model, is explained as (self-) explanation, i.e. as internal re-elaboration and re-structuring of existing knowledge promoted by the verbalisation of that knowledge (Van Lehn, Jones & Chi, 1992). Explanations to others and self-explanation are deemed to be equally effective for learning and consequently the difference between group learning and individual learning is minimal.

Miyake (1986) presents an approach that focuses on the effect of roles that peers take on in a group learning situation. In research with dyads, she distinguishes the 'problem solver' and the 'monitor', the former actively solving the problem, the later to observe what the 'problem solver' is doing from a slightly broader perspective and checking its validity. The presence and attention of another group member trigger the problem solver's re-interpretation of her own attempts. Collaborative learning is described as an "iterative chain of re-interpretation" (Miyake & Shirouzu, 2002) that enables the gradual integration of solution variations. The aspect most important for the present discussion is the emphasis on the differences in interpretations and viewpoints as the source of learning, as opposed to convergence. Students may learn different things from the same session and learning occurs also in the absence of agreement.

The individualistic view can be characterised as follows:

(1) learning is the acquisition of abstract knowledge and occurs in the mind of the individual

(2) collaborative activities affect internal mental representations by promoting specific cognitive processes

(3) these processes are often the same operating when people learn alone, exemplified by the essential equality of the effects of explanation and self-explanation (Chi et al., 1994)

These views explain the higher level of abstraction characteristic for representations generated in collaborative situations as the result of internal elaborations of knowledge, elaborations that are promoted by peers, but not influenced by their knowledge.

2.3.8 Summary

These sections have located the thesis' main theoretical commitments with regard to collaborative learning. The sections introduced the 'individualistic-mentalistic' view of collaborative learning, and compared it to the contrasting and more common 'social' view. Also, a strict and a loose view of collaborative learning have been introduced. While the strict view strikes as defining clearly its object of research and locating it within the general research on learning, the loose view adopts a definition of learning that is consonant with traditional learning research. It is argued that equating learning with joint meaning-making captures too few instances of learning, i.e. significant individual learning occurs in collaborative learning situations that is not due to joint construction of knowledge.

It should be emphasised that most researchers see in collaborative learning the operations of both individual and joint knowledge construction, and that a clear judgement regarding the relevance of either is still outstanding (cf. Dillenbourg et al., 1996). One major obstacle to provide a definitive answer is certainly the inability to individuate clearly the source of knowledge of an utterance or other forms of communication. This can be illustrated with reference to Schwartz' (1995) studies. As mentioned shortly above, Schwarz' dyads produced descriptions that were more abstract than descriptions produced by its most able member. The explanation offered pointed out that the communication of one's conception needs to be more abstract in order to bridge eventual differences in interpretation. The main question then must focus on the source of knowledge of this more abstract description: is the abstraction generated only on the individual's knowledge, for example, through a mechanism of abstraction from one example, or does it take the interpretation of the peer's knowledge into account? In a sense, is the more abstract description an attempt to bridge between two known interpretations or is it constructed by default? The requirement that knowledge must be expressed, and displayed, is of only meagre help in deciding this question. Indeed, the interpretation of an utterance varies significantly and utterances seemingly devoid of knowledge for one recipient may have much significance for another. Ambiguities are subjective, too, and hence the lack of disambiguation is a weak argument against the mechanism of joint meaning-making. The opposition

individualistic vs. joint knowledge construction should be seen in a Kuhnian way (Kuhn, 1962): the views perceive phenomena differently, and their views are internally coherent: where the 'individualistic' view sees the construction of abstract knowledge based upon the individual's knowledge and her interpretation of her peer's interpretation, the 'joint' view see joint meaning-making.

2.4 Designing learning

2.4.1 Introduction

One of the two main aims of this thesis, to improve an educational practice, is realised by proposing and testing a learning design. Designing learning is common for practitioners and has indeed in a form always been done: teachers, for example, have often changed the learning material or learning task in order to achieve more effective learning. Designing education has until recently not been formalised explicitly in the research community or discussed in these terms. However, in the last decades the concept of 'education design' has become a quite frequent topic of discussion and research, and important 'dimensions' (such as the relation between a learning theory and a design) have been identified.

The following sections introduce the notion of 'learning design'. It is introduced by, first, presenting a few of the most important recent innovations in learning design, and then by discussing characteristics of them that are relevant for this thesis. It will be shown that recent innovative learning designs made use of new insights into cognition and learning, and that models and theories of learning play a significant role in design. This will provide a justification for basing the proposal of this thesis on a model of learning.

The thesis adopts a broad definition of design: it includes the specification of components of an education design that are essential to attain learning goals. The components include the learning task, the material and the learning environment. These components are conceptualised as 'design targets', and discussed in section 2.4.4.

First, however, a short introduction to the method of 'learning design studies' will be given. By discussing this relatively recent methodological development, some of the most important concepts in learning design (e.g. 'learning ecology', 'engineering education') will be introduced.

2.4.2 The 'design experiment' method: conceptualising learning design

The recognition that learning cannot be studied without taking into consideration the social and material environment within which it takes place (e.g. Lave & Wenger, 1991; Salomon & Globerson, 1989) has led some in the education research community to adopt the "design experiment" methodology. Its most conspicuous characteristic is the a priori specification of parts of the learning environment resulting in control over the variables affecting the phenomena investigated. In contrast to the traditional experimental paradigm, where only one or very few variables are focussed on, design experiments study the influence of a quite large number of factors on learning. Cobb et al. (2003) point out that the function of design experiments in education is to understand the learning ecology, i.e. the "complex, interacting system" within which learning takes place. This system is composed of "multiple elements of different types and levels" (ibid., pg. 9), such as the learning material, the teacher or tutor support, the task, the form of communication and the material support for learning (books, a blackboard, etc.).

Following Brown (1992), design experiments are best described as efforts to "engineer a learning environment". The metaphor of engineering is being used to, first, emphasise that the elements composing the system are not just a collection of interventions or factors, but form rather an organic whole. A modification of one element may result in a different behaviour altogether since the elements interact. The use of design experiments in education research derives from the holistic nature of education what renders the isolation of specific individual factors difficult or moot for research purposes. A second meaning of the engineering metaphor points to the interventionist nature of the experiment: the methodology addresses the need to generate learning environments where specific forms of learning are promoted and supported. They have hence a theoretical as well as pragmatic value.

Learning design experiments specify and study several factors at once, though normally they focus on a few specific once. By design is hence meant not only the material support for learning, such as, if computers are used, the interface, but most essential aspects. This includes the learning material, the learning tasks, the teacher or tutor support, the group composition (if applicable), and even larger educational policies. Examples of design experiments are yet few but they vary quite widely: an experiment may address a specific form of learning in an environment through a one-time prescription of the environment and evaluation of learning (e.g. Botha et al., 2005) or may involve the active intervention of the researcher over a long period of time who reacts to intermediate learning progress (Cobb & Steffe, 1983). They may involve learning in a particular and well-defined domain or may study the effects of organisational changes on educational experiences.

The expected output of a learning design experiment is practical as well as theoretical. It is practical because researchers are interested in the question "which design works" and "which design supports best the intended learning processes". However, the merely practical purpose of design experiments would lead to constant and unfruitful interventions addressing local deficiencies revealed through assessments of learning without identifying what produces these deficiencies. Cobb et al. (2003) emphasise the theoretical purpose of a design experiment: its output should be a theory about the process of learning as well as the means to support that process. If a design experiment involves multiple stages and interventions of the researcher, then these interventions need to be grounded in a model of learning. The theoretical output would permit then to adapt the design proposal to new circumstances.

The basis of design experiments can vary from specific learning goals described as 'knowledge or skills to be acquired' to much more pragmatic educational needs. For example, a design experiment may be carried out to investigate the most proficient uses of a new technology in education, or to identify the learning trajectory of a classroom community learning in a particular domain.

The identification of learning needs and learning goals are at the origin of a design experiment, and they are normally the criteria upon which the effectiveness of a design is assessed. Again, here the specification of needs and goals varies widely. For example, they may be general needs such as the "need to familiarise students with computer technology" or "to provide a more flexible access to education through the use of computer technology" (Reimer & Rader, 2006), or very specific needs identified as specific proficiencies in solving problems in a certain domain (Cobb, McClain & Gravemeijer, 2003).

The pragmatic function of design experiments and their value as "test-beds for innovation" (Cobb et al., 2003) renders a justification of studies less dependent on existing research. A design experiment could in principle be carried out without justification of the usefulness of the design except a justification based on the innovative value of the design. There is indeed typically a significant discontinuity between traditional forms of education and the ones designed and tested as design studies. As Brown (1992) has successfully argued and shown, design studies may even prompt a reversal of the fortune of phenomena deemed to be deleterious for research into the phenomenon to be engineered, or force a reconceptualisation of traditional notions in education (e.g. Lobato, 2003).

The methodology of learning design studies has provided designers of education and educational systems with a few essential high-level concepts. First, the method emphasises that there is a discontinuity between the original and a redesigned educational practice. That

discontinuity derives from the fact that an education design is to be considered as a 'learning ecology', i.e. a complex system of interacting components where the modification of one component may lead to a different behaviour of the other components. This renders a traditional experimental study of an education design difficult, because a comparison can be made between the original system and the redesigned one only on the basis of the educational effectiveness. The specification of learning goals becomes therefore important: they provide the basic point of reference when assessing the original and the redesigned practice.

The design study methodology also incorporates the notion that what education design attempts to accomplish is the 'engineering' of forms of learning. Specifically, it attempts to construct a system constituted of different components (the teacher, the learning material, the task, etc.) that *promotes and supports* a specific from of learning. The most important factor in the evaluation of that system is, again, whether it accomplishes what it is designed for, i.e. whether the learning goals are met.

Lastly, the design study method emphasises also the role of theories or models of learning as the foundation for design proposals. The role of theories or models is to provide coherence to design interventions. Indeed, an education design may be tweaked until it promotes the sought learning, but such tweaking may be done indefinitely unless the reasons for learning deficiencies are identified. Theories and models of learning are essential here because they allow identifying those reasons, and hence can guide interventions.

2.4.3 Learning design: frameworks, models and principles

2.4.3.1 Introduction

Designing education is a core concern in education research. While education has always been designed, in the sense that practitioners have assessed the effectiveness of, and modified and adapted educational practices, only recently efforts have been made towards an explicit specification and formalisation of education design. There are several motives behind this development. Relevant for the current discussion are the following two factors: first, the development of new learning models arising from the dissatisfaction with traditional teacher-centred models and second, the role of technology, and especially computer technology, in education. These two factors act sometimes synergistically: the need to base computer-supported design on viable theoretical models of learning has led to a renewed interest in such models, and even to a re-evaluation of dormant theories of learning.

The following sections describe approaches to learning design, and a major attention will be given to extant work on learning design whose design specifications are derived from theories or models of learning. The first section introduces a generic framework for learning design. The framework exemplifies what is meant in this thesis by learning design: learning design is the prescription of relevant features of learning (such as the task, the tutor support and the learning environment) aimed at serving learning goals.

Then, three specific design proposals are presented in a summary form. They exemplify how theories or models of learning inform design guidelines. A subsequent section focuses on how cognitive models have been used to design education. This section discusses also the difficult relationship between cognitive and educational research. The last sections then continue the 'path from theory/model to design' by presenting the design 'targets', i.e. what, in practice, are the objects that are designed. The focus will be on three targets, the task (activities), the learning material, and learning tools supporting learning processes. Though design targets are many more, including tools supporting communication, interaction and collaboration, the focus in this chapter is on the task, material and support tools because these are the design targets of the proposal espoused in chapter 7.

2.4.3.2 A generic framework of learning design

A high-level and abstract way to formalise education – and to provide a 'language' for education design – is to distinguish learning objectives, persons, roles, actions, the method and the environment (Koper & Olivier, 2004). Such a formalisation is especially adept at capturing educational practices that are characterised by frequent changes in roles and activities, and where roles and activities are not solidly tied to specific persons. Practices informed by the socio-constructivist paradigm can be formalised well within this framework. Here, indeed, the role of teachers and students is not well defined from the outset: students may take on the traditional role of the teacher and carry out activities that in a more traditional form of education were reserved for the teacher.

This description of education rests on the assumption that education design is the application of a pedagogical model for a specific learning objective targeted at a specific user in a certain environment. Education occurs, within this framework, as the people involved carry out activities aimed to satisfy the learning objectives, interact with other learners, and are supported in these activities by the practical environment. The learning design specifies the processes that should occur so that the users can achieve the learning goal.

Within this framework, at the centre of an education design is an educational method. The centrality of the method derives from its role as coordinator of activities, roles and people. That is, it is the method that assigns people a specific role that is characterised by one or more learning activity. The method specifies also, and importantly, the sequence of activities and the sequence of roles taken on by people. For example, while in a first stage of learning the teacher explains an example, in mid-stage students may be asked to generalise over the example, and, in later stages, students may need to provide explanations for new examples. This coordination of roles, activities and associated environments is what should permit the learner to attain her objectives.

The activities occur within an educational environment. The environment consists of learning objects and services that are to be used during the performance of the learning activities. The environment includes the learning material as well as tools for communication, serialisation or other facilities that support the activities. A further component of learning design is the prerequisites for learning. Prerequisites are, for example, the knowledge that students bring to a learning session. Activities will need to be included in the design to account for students' knowledge. For example, this knowledge may need to be specifically elicited or evaluated; or, if students have misconceptions about a domain, they need to be specifically addressed.

The framework discussed above is one example of how to formalise an educational practice. The framework identifies the major components of education: the learning goals, the people involved, the method, the tasks and activities, the learning material and the practical learning environment (learning and communication tools). These distinctions provide a useful basis for the distinctions of the design targets of this thesis: a design is proposed that should satisfy the learning goals, and the design guidelines specify what task should be used with what learning material and in which learning environment. The notion of design 'targets' is discussed in section 2.4.4 in this chapter.

The framework described learning design at a high level of abstraction. It allows framing design proposals within a design 'language'. While generated in order to capture and prescribe educational practices inspired by the constructivist paradigm, it does not specify the components more concretely. Several other frameworks for education design have been proposed that specify these components: they prescribe specific learning objectives, learning activities, and learning tools. The following paragraph will present one design proposal that has had a major influence on the design of education, CSILE (Scardamalia et al., 1989).

CSILE

A method-centred framework, such as the one presented above, positions the coordination of people, roles and activities at the centre of the design. That coordination is realised by the educational method. The environment is then specified on the basis to satisfy the need to support the activities. The design of learning tools, including computer-based learning tools, is hence subordinate to the activities. While the unidirectionality from activities to supporting objects is common in education design, other approaches to design have been proposed.

The most notable is CSILE. CSILE may be regarded as one of the main originators of education design proposals. It is also one of the few design implementations that has been successfully adapted locally. The inspiration for CSILE is the paradigm of situated cognition (Hewitt & Scardamalia, 1998).

This paradigm sees cognition as being tied to the environment, with cognitive tasks making use and adapting the tools offered by the environment. Learning, according to this paradigm, occurs through the interaction with the environment, including the social environment (e.g. other students, pupils, the teacher), and proficiency is achieved when people are able to carry out tasks in an environment. The paradigm places major emphasis on artefacts that are used for learning. For example, textbooks, essays, reports, etc. are extensions of a person's cognition: they are both products of cognition as well as the tools upon which cognition is based (Perkins, 1993; Hutchins, 1995, Kirsh, 1995).

CSILE is an implementation of the principles of distributed cognition. It was proposed to foster and support the distribution of knowledge and processes; its aim is also to elicit knowledge that would otherwise remain dormant. By supporting pooling of knowledge, collaboration and connectivity between students and teachers, and especially students and students, the design of CSILE aims to develop an environment where knowledge is jointly constructed and where that constructed knowledge is stored in knowledge artefacts. It is an example of an education design where the relationship between the learner and the environment is bi-directional: the conception of the learner affects how the environment is designed, while the design of the environment affects how the learner acquires knowledge. In a more general sense, education is designed here within the conception of design that 'artefacts do cognitive work and also change the cognitive work of practitioners' (Dowell & Long, 1989).

CSILE was also notable in placing a major emphasis on the use of computer technology for education. It was assumed that computer technology would be able to implement those principles that are essential for more effective education (Salomon, 1998). Several functionalities of computers lend themselves to connecting people, generating a community of learning, permit easier access to learning resources and allow the creation of knowledge

artefacts that are generated jointly and can be reused by all. It could be said that the CSILE project presented a new form of education where computers played a central role. In a sense, it is a proposal for education design that places much more emphasis on the environment rather than on specific learning activities supported by an environment. As such is differs significantly from a design proposals presented in the next paragraph.

2.4.3.3 Cognitive models and learning design

One way to render more certain the relations between the objectives of learning and the desired learning processes on the one hand, and design guidelines on the other is to specify preconditions of learning (such as the knowledge students bring to a learning sessions), the learning processes by which that knowledge is used and transformed, and the kind of knowledge that students should gain from a learning session. Specifications formulated in this way are local: they are applicable only to a small range of domains, and a small range of end-users. Design guidelines derived from such specifications are equally local in character: they may be usable only in a narrow context of learning.

The design proposed in this thesis is of this character, and at the opposite spectrum of generality that characterises the earlier described design proposals. It rests on a relatively specific cognitive model of learning rather than a generic learning theory or learning model. In this section, it will be described how cognitive models have been and can be used to inform learning design.

Research in the cognition and psychology of learning is only partially influential on education. Education is often seen as a practitioner's realm relying on its own conceptual tools to frame the phenomena of interest to it. Education occurs in complex settings and multiple intervening factors contribute to the success or failure of education. Cognitive science research targets often single phenomena in controlled settings, reducing thus their usefulness for education.

Some cognitive science research is however still influential in education. The cross-disciplinary fertility is to be attributed to some models and paradigms whose view has also challenged traditional cognitive science assumptions. They rely on specific views of knowledge, cognition and learning.

Schank's (1983) case-based reasoning model may be seen as a precursor of integrating cognitive science and education. The model proposed that problem solving relies on earlier experienced problem solving episodes whose solutions are adapted to a current problem; learning, according to the model, is the memorisation of experiences acquired during a goal-directed activity. These activities would form knowledge structures bound by a common goal,

would be memorised in an organised knowledge base, and would be retrieved by similar problem solving situations. Several projects have translated the model into the design of environments where students should learn in authentic contexts (such as a scientific laboratory) with authentic tasks (such as scientific inquiry) and are assigned real-world problems (Guzdial et al. 1997; Edelson, 2001, Schank, 1994).

A likewise influential approach to cognition on education is the paradigm of situated cognition (Hutchins, 1995). It emphasises that cognition is tied to its environment, and that knowledge acquired in a specific context remains "welded" to this original occasion of use (Lave & Wenger, 1991). Knowing and doing is, according to this paradigm, tightly interwoven. Brown (1997) advocated, on the basis of this paradigm, to modify teaching practices in schools by immersing students into real-world problems or simulations thereof. So, for example, instead of teaching physics through traditional textbook examples and rules, pupils should engage in real-world problem solving, such as explaining situations they encounter in their real life.

These and other views of cognition have influenced education and education design as, as it were, models kept in the background but always present as guiding inspirations. Cognitive science research has however also contributed to education by conceptualising specific phenomena of learning, providing knowledge representation frameworks and investigating mechanisms of learning.

Of particular importance has been misconception research. Investigations into misconceptions of pupils or students have identified the role of previous knowledge in constructing new knowledge. This research has contributed substantially to implement the constructivist position in education. By identifying the kinds of misconceptions students possess in specific domains (especially physics, e.g. diSessa, 1993), educational practice has been able to design education by specifying the material, task and tutor support. Education design, in this role, aims to raise the students' awareness of misconceptions and the means to address them. Likewise, cognitive research that identifies learning in terms of re-descriptions of representations (e.g. Karmiloff-Smith, 1992), from experiential and perceptual representations to linguistically encoded representations, has been influential in helping to specify tasks and tutor support (Philips & Tolmie, 2007). These may be prime examples of how knowledge representation frameworks and mechanisms of learning used and deriving from cognitive science research have led to revisions of educational practices.

However the 'translation' from a model of one or a set of cognitive phenomena into specific proposals of education design is difficult. A cognitive model does not lend itself easily to a design specification that is able to target all the essential components of an educational setting, such as material, task and tutor support. Moreover, the same cognitive mechanism of learning

(intended as a transformation of knowledge into another representation) can be achieved through several design interventions. For example, generalisation over an instance can be prompted through an appropriate task, through the presentation of multiple instances or through explicit support by a tutor. In a sense, the complexity of education is captured only with substantial difficulties or even not at all by specific cognitive models. And indeed, as Anderson & Schunn (2000) point out, the mutual influence between research on cognition and educational research is, with the exception of cognitive models acting as inspirations in the background, still quite low. To render the implications of cognitive research more amenable for education, the authors emphasise the need for a "rigorous theory that bridges the gap between the detail of the laboratory experiment and the scale of the educational enterprise".

A greater challenge to the use of traditional cognitive science in education comes from the conception of learning as legitimate peripheral participation (Lave & Wenger, 1991). The authors conceptualise learning as the participation in professional activities, and the acquisition of a professional identity. Though the authors' interest is on the social aspect of learning, they also explicitly reject the notion of learning as the abstraction of decontextualised knowledge that may then be applicable to situations outside it context of acquisition (Lave, 1988). Though they admit that general knowledge is acquired, they deny that this knowledge can be reused in situations that are not contextually similar to the situation where it was acquired. Clearly, this view challenges one of the core assumptions of traditional cognitive science research that focussed mostly on how people acquire abstract knowledge from examples or problems. The authors tap however into a problem that has eluded traditional cognitive science research: while it may be possible that abstract knowledge is acquired, the problem of using that knowledge remained unsolved. Reference to the role of practice in learning (e.g. Anderson & Schunn, 2000) have been made as auxiliary hypothesis to maintain the original conception, but the central role of practice has not been recognised. In a sense, while the lack of transfer observed in experiments (Lave, 1988) was normally attributed to as yet unexplained factors, Lave & Wenger (1991) simply dismissed the assumption on the acquisition of decontextualised knowledge, and emphasised the role of practice.

Lave & Wenger's influence on education and other authors taking similar positions on learning can already be seen: it has become more common to present pupils and students real-world examples, and to increase the similarity between the context of acquisition of knowledge and the context of use. The increase of problem-based case-based learning in higher education may be attributed to this new conceptualisation of learning. The role of cognitive science is now to describe what is meant by contextualised knowledge, to describe how learning in real-world contexts occurs and, methodologically, to study learning in the real-world rather than in a laboratory setting.

2.4.4 Design 'targets'

The design proposal is characterised by micro prescriptions: it prescribes very specifically the task and the material (including the sequence of presentation). The practical support for learning, i.e. the learning environment, is prescribed to a lesser degree, i.e. some flexibility in implementing the design proposals is permitted. The three prescriptions are the 'design targets' of the proposal.

The distinction of education designs into design targets could be seen as violating the spirit of education design. Indeed, a separation between, for example, task, material and support is contrary to the idea of a 'learning ecology' (Cobb et al., 2003): all components of an education design act 'in concert' to achieve the learning objectives.

However, design proposals often do emphasise the design of one target over another: they may specify the task and only subsequently specify learning tools required to support that task; or, as in the case of CSILE, the learning environment is specified first, with the activities to be carried out in the environment specified with the purpose to exploit the opportunities offered by the environment.

The design proposed in this thesis places the major emphasis on the material and the task, with the environment being specified for the purpose to support learning activities and processing of the learning material. A strong emphasis on learning activities is common in education design, including computer-supported design proposals. Design emphasising the specification of the learning material is rather infrequent, with the exception of generic specifications regarding the types of material (e.g. real-world problems, cases) and their characteristics (e.g. authentic).

2.4.4.1 Designing learning though learning tasks

The specification of learning tasks is a common if not ubiquitous part of education design proposals. The rationale behind specifying tasks is to promote processing of knowledge and information. Activities may specified in a generic form, such as 'inquiry' (Edelson, 2001) or a more specific form such as 'applying knowledge' or 'abstracting rules'. Specification of tasks may be based on a model of learning that describes how the processing of information results in the acquisition of knowledge and competencies. For example, a model of learning may describe the acquisition of problem schemata as resulting from the abstraction of common features of multiple structurally similar problems. A model of this kind would translate into a specification of learning tasks aimed at promoting abstractions from problems.

When prescribing educational tasks, it is common to specify a sequence of them, aimed at processing initial and intermediate states of representations of the learning material. For example, students may be asked to – in this sequence – reflect on specific issue and generate a set of conjectures, compare these conjectures with real data, propose alternatives, investigate these alternatives and finally explain and explore the alternatives (Edelson, 2001). Or, students may be asked to observe an event, try manipulations of the event, predict outcomes, compare their predictions with actual outcomes, and finally abstract principles from the comparison (Vahey, Enyedy & Gifford, 1999).

Of particular importance for the design proposal offered in this thesis is the specification of tasks promoting analogies. The simplest kind is clearly an instructional analogy, where students are asked to reuse an earlier solution or interpretation on a new problem. Though analogical reasoning occurs commonly in learning, and tutors sometimes encourage it by injecting structurally similar situations into a discussion (Lajoie, Wiseman & Faremo, 2000; Yerrick & al., 2003), the explicit use of instructions fostering analogies is not widespread. Instructional analogies are effective in promoting the acquisition of theoretical concepts (Newby, Ertmer & Stepich, 1995) especially in undergraduate education, but are not conductive to learning higher-order thinking skills (Baker & Lawson, 2001). In a sense, analogies help students to acquire domain-specific substantive knowledge, rather than generic procedural knowledge.

Another important form of designing tasks occurs by assigning different roles to collaborating students. It should be pointed out that what are designed in this way are not strictly activities, but rather interactions. However, roles, such as the 'tutor' and 'student' (reciprocal teaching; Palincsar & Brown, 1995), the 'explainer' or 'conceptualiser' and the 'monitor' (Miyake, 1996), are associated with different activities and also different learning processes. The design of the interaction here entails an implicit design of tasks.

2.4.4.2 Designing learning through the material

Design proposals explicitly targeting the material are infrequent, although, as mentioned, many recent design proposals use a particular form of learning material. Contextualised scenarios, real-world problem, or complex cases are used to bring more authenticity to learning, and to implement learning models such as case-based learning or situated learning. The presentation of a problem or case affects how and how well students learn. For example, complex cases are normally presented in discrete units consisting of a statement of the problem, a narrative description of an expert solution, and a set of study questions (Linn & Clancy, 1992; Redmond & Phillips, 1997). The distinction into discrete units helps students to overcome difficulties to

grasp the complexity of a case. In a sense, the specific design of the presentation of the case scaffolds students' learning.

Another form of designing learning through the material is the jigsaw method (cf. Shirouzu, Miyake & Masukawa, 2002). It separates a body of knowledge into a few small units and assigns them to individual students. To solve a problem, the entire knowledge is needed, and hence the distribution of knowledge over different individuals promotes collaboration and knowledge integration. As many others, this form of design is not limited to how the learning material is used, but is also a design promoting collaboration and interaction.

Of particular interest for the thesis are the access to learning material and the access to background knowledge. The accessibility to the learning material is considered here a form of design because it does affect how students learn and what is learned. Computers offered at first the opportunity for students to access learning material and background knowledge in a different way: computers made the access much faster and permitted the access a much larger body of knowledge. The growth of the Internet enhanced the opportunities further. This new form of educational environment was meant to promote the acquisition of abilities associated with learning to learn and life-long learning (Linn, 2000). By being required to sift through a large body of knowledge students would acquire necessary skills for knowledge navigation and the ability to quickly assess the relevance of knowledge for a particular problem. Further, all these activities would be guided by their own knowledge and their own conception of the problem they were solving; and hence, the constructivist paradigm would be well implemented.

However, some studies have shown that a large body of knowledge cannot be explored without students losing their sense of location (Schuh, Gerjets & Scheiter, 2005), that they were not able to assess the relevance of knowledge they came across, and, most importantly, that their navigation behaviour was unguided and exploratory only. Salomon (1998) argued that an unrestricted access to a large body of knowledge would lead to the "butterfly defect", i.e. student would acquire a knowledge base formed through associations reflecting the architecture of the knowledge base they navigated, instead of acquiring a robust, semantically connected knowledge base. What becomes lost in environments that permitted unrestricted access to knowledge was goal-directed, top-down search behaviour, the kind of behaviour required to build a robust knowledge base.

It should be pointed out again, that most design proposals surveyed for this chapter do, in one form or another, design learning by specifying the learning material. However, research reports on design proposals and projects are only scantly referencing how the design principles have affected the choice of the material and the choice of the presentation of the material. In a sense, not much explicit research has addressed the opportunity to design learning through the learning

material, but rather the choice of the material relies on experiences of the researcher or practitioners.

2.4.4.3 Designing learning through tools

Learning tools are designed to support activities in a learning environment. They may be of very general nature, such as tools to navigate through learning material or are specific, such as when they are supposed to promote and support a learning task. Learning tools are often designing 'at the service', as it were, of learning activities, though in some learning designs, such as CSILE, tools are of primary importance. CSILE was indeed designed to create and support communities of learners.

For this thesis, the design of tools is of rather low relevance because the focus of the design offered in the thesis is the task and the material. The thesis' design proposal relegates tool into the role of supporting the learning task. However, a short overview over the use of learning tools in education is given here.

Learning tools can range from simple notebooks to sophisticated simulations, where in the latter case the tool would be designed to support a highly specific form of learning. The notion of learning tools adopted here includes also tools designed to support communication, collaboration and interaction.

The introduction of computer technology into education has increased the opportunities to include learning object into educational environment. In particular, constructivist pedagogical approaches have seen in computers their most useful 'partners': they have seen them as the best way to realise the constructivist paradigm (Salomon, 1998). For example, computer technology gives students better opportunities to construction knowledge jointly through, for example, shared electronic whiteboards. For the purpose of exemplifying the 'marriage' between constructivism and computer technology, an exemplary project, SenseMaker (the Knowledge Integration Environment; Bell, Davis & Linn, 1995) is discussed here shortly.

KIE was planned as software to support students' scientific argumentations. It implemented the constructivist principles that students should learn by constructing their own knowledge with a computer interface that permitted students to create arguments visually. Specifically, the interface is separated into components of argumentations (such as 'claim', 'warrant', 'data', etc.), and the tasks given to the students promoted both the generation and evaluation of argumentations. The software also supported collaboration by giving students the opportunity to construct arguments jointly and to evaluate them. The role of the tool in KIE is to scaffold the student's learning of science, and specifically their learning of how to relate data to theories.

The project may be regarded as prototypical for several other important computer-based design proposals that function as reference points in the research on education design: it promotes collaboration, uses tools for visualisation of thinking, and promotes the active engagement of the student with the learning material.

2.4.5 Summary

The previous sections have introduced the notion of 'learning design' and several important notions related to it. In this thesis, a broad definition of 'learning design' is adopted: it includes components such as the task and the learning material (cases and background). This definition of learning design is rather unusual: normally by it is meant only the design of the learning environment. However, as has been argued and shown through examples such as CSILE, education design is aimed to 'produce' a specific learning outcome and to satisfy learning goals, and since the task and the learning material are certainly conductive to this aim, they are included in a specification of an education design.

It has also been shown that learning design can be based on generic learning theories or more specific models of learning. For example, the view of situated cognition and learning and more specific models of learning such as the 'inquiry model' were influential for several innovative designs.

The last three sections have discussed in detail the design 'targets', i.e. the components of the education design that will be specifically prescribed. It has been pointed out that, in contrast to many other design proposals, the thesis' proposal emphasised the specification of the task and the material over the specification of the learning environment. These specifications will be discussed in detail in chapter 7.

Chapter 3

A cognitive framework for studying learning with cases

3.1 Introduction

This chapter introduces a framework for studying collaborative learning with cases from a cognitive perspective. The framework is complied from the review on the literature on learning with and from examples, on learning with and from problems, and experiential and analogical learning. The framework will guide the analysis and interpretations of the discussions presented in chapter 4, 6, and 7.

The final output of the review is a set of several generic cognitive processes and their cognitive products that are the basis for the analysis scheme applied to a study on current practices in case-centred learning.

The presentation of the processes and products of problem solving and learning presented here rely on some assumptions about the structure and organisation of knowledge, and make distinctions between specific types of knowledge (conceptual, episodic, etc.). This distinction is

necessary because the interpretation of cases uses specific forms of knowledge, and further some models introduced here describe learning as a transition from one type of knowledge (episodic) to another (general, domain-specific conceptual). Special emphasis is made on a generic view of problem solving whose core assumption is that problem solving is aided by past problem solving episodes stored in memory. This requires the introduction on assumptions on memory access. All these assumptions are introduced first. Then, two sections describe research on problem solving and research on learning that is pertinent for describing case-centred learning. Prominence is given here on the topic of learning from problem solving, and learning from studying complex examples. These sections present the current view on experiential and analogical learning, both forms of learning that, with some adaptation, are the basis for describing learning with cases. These sections also introduce and discuss conceptual learning and the phenomenon of conceptual change.

3.2 Assumptions

3.2.1 Knowledge representation assumptions

In this thesis, it is assumed that knowledge is organised in elements and relationships between elements. This corresponds to the traditional knowledge representation framework of 'structured representations'. Structured representations permit to represent complex situations as a combination of simpler elements and make the relationships between elements in a situation explicit (Markman, 1999). The use of structured representations is however not only a pragmatic device, but, according to some researchers it captures faithfully how people represent situations and how they think (Gentner & Lowenstein, 2002). For example, describing that a person P has caused an event E would be represented with two elements (P and E) related through a causal relation, all components of the resulting structure being atomic elements of thinking. Similarly, spatial (e.g. above, right), temporal (e.g. before, after) and also dynamic relationships (e.g. proportional, linear) are assumed to be atomic elements of thinking (Lakoff, 1990).

The use of structured representations has its roots in Gestalt psychology, and maintains the core assumption of it: atomic elements representing objects in the world are given meaning in dependence of their relation to other atomic elements. The notion of 'meaning' is intended here as providing an interpretation to the elements, and the structure as a whole. For example, the person P that caused event E is assigned the role of 'causing agent' by way of his being part of the situation.

Like Gestalt psychology, the framework of structured representations assumes that giving meaning to a situation is a holistic process: it is the situation that causes the person P being

assigned the role of causing agent, but it is also this role that contributes to the overall meaning of the situation. The interdependency between the interpretation of the situation and the interpretation of its constituting elements has several implications for models of cognition. For example, the identification of similarities and the identification of differences between situations are, according to this approach, interdependent: since it is a structural relation that identified the situation, what is similar depends on what is different, and vice versa (Markman & Gentner, 1996). Similarity comparisons, according to this view, cannot occur between individual features, because it is the structure that determines the interpretation of individual features.

Further important notions associated with the view of structured knowledge representation are the notions of strength and coherence. It is assumed that, similar to perceptual organisations, a structure that is able to relate elements coherently has a strong influence on the interpretation of the individual problem elements. Once an interpretation is coherent and accepted, people have difficulties to impose a different structure on a problem or case. This derives from the holistic nature of the structure: imposing a different structure would require re-interpreting all problem elements and a radical change in re-interpretation would occur in the form of an all-or-nothing process (similarly to a Necker cube). Re-interpretation may occur if one or more assumptions upon which an earlier interpretation is based are found to be incorrect. Replacing these assumptions may lead to the replacement of several others. In other words, while being difficult to accomplish, a re-interpretation may entail a change in several assumptions and may lead to substantial learning. This form of problem solving and learning is known as conceptual change, a phenomenon that will be discussed in section 3.3.5.3.

A special kind of structured representation is scripts that were developed to represent events (Schank & Abelson, 1977). Scripts capture goal directed behaviour: their core representational element is an actor's goal and the script represents which steps an actor normally takes to achieve it. Scripts were proposed to capture people's understanding of everyday situations in the absence of full information about the situation. The notion of scripts has some importance for this thesis for two independent reasons: first, some case-centred educational practices use events in order to promote reasoning about planning and carrying out projects. This form of case is especially used in business and management education. A description focussing on an actors' (e.g. a company) goal and the way it has been reached is used as the basis for learning about the influence of variables (e.g. other events, organisational structure) that have affected the success or failure of the project. In this way, students are prompted to apply codified and theoretical knowledge. While goals and plans are not representational elements in the cases used in the present studies, the description of learning with cases offered in this thesis should be generally applicable to several types of cases currently used for education. Second, the notion of plan, an essential element of scripts, is similar to the notion of procedure in that both represent the

execution of a series of steps that need to be adapted to a current problem situation. The notion of 'solution procedure' will be useful when describing problem solving and learning in study 3 (section 8.4)

3.2.2 Surface – structure distinction

The distinction between the surface and the structure of a problem or case is used in several descriptions of learning and problem solving and most prominently in research on analogical learning. The distinction captures the difference between the perceptual, atomic elements of a problem or case (the surface) and its 'point' or 'story' (the structure). The distinction rests on the assumption that a relatively generic solution (intended as a principle not a rule) can be applied to a range of problems that differ in surface representation. The classical example is Duncker's 'radiation' problem that has an analogue solution to the 'fortress' problem (Duncker, 1945). The core process of episode-based problem solving makes use of this distinction: problem solving occurs by retrieving a structurally similar past example from memory and adapting it to a present problem.

Within this approach the distinction between problem representation and problem solution is relatively blurred because once the problem is appropriately understood, i.e. structured, the solution is straightforward. For example, once the radiation problem is understood as being one of 'multiple convergence', the solution is easily found. Similarly, once the problem described in the 'flight of the Phoenix' is understood as being one of a distribution of resources, the solution can be easily derived (Hammond, Seifert & Grey, 1991). These two stories however relatively simply structured. More complex problems, such as physics problems, have a multi-layer structure. Imposing a partial structure on such a problem would not solve it completely, but it would certainly make it easier to solve. The 'equivalence' of structure and solution highlights however the notion of structure and its importance in problem solving.

In research on problem solving and learning, the notion of structure is sometimes synonymous with 'understanding' and once people have 'structured' a problem, this is equivalent to having understood it (cf. Markman, 1999). Examples for this use of structure abound in research on example-based and analogical reasoning. For example, understanding how simple physical devices work (e.g. Forbus & Gentner, 1986), or why people in a story behave the way they do (Winston, 1980) is described in terms of structure: the elements of the problem are related by knowledge that captures the essential dynamic of their interaction.

The surface – structure distinction is also used to describe the differences of encoding in experts vs. novices. As will be described in detail in section 3.2.4.1, novices focus primarily on surface features of problems, while experts are able to discern a structure in a problem (Chi, Feltovich

& Glaser, 1981). This gives experts cues for retrieving structurally similar past problems what increases the possibility that a useful past example is retrieved. Novices' reliance on surface features means that they retrieve superficially similar but structurally dissimilar past examples. Since structurally similar problems can be represented in a multiplicity of different surface features, such features are not able to target the most useful, i.e. the structurally similar, past examples.

The overlap between structural representation and solution mentioned above must be, considered this logic, qualified: complex problems, such as those upon which expert – novice differences are investigated, may be represented at multiple levels of structure, and an initial encoding in structural features may not capture the core structure of the problem, but only the structure at an intermediate level. Structural encoding hence merely restricts the range of targeted past examples. It remains however much more efficient than surface encoding that normally retrieves a range of structurally different past problems.

It should be pointed out that it is normally assumed that the surface representation does not reflect the structure of a problem. The opposite assumption, labelled the 'kind world' hypothesis, is not thought to be valid (cf. Gentner & Medina, 1998).

3.2.3 Types of knowledge: conceptual knowledge and episodes

The two kinds of knowledge most relevant for the thesis are conceptual knowledge and episodes. The description of the approach to modelling learning with cases in this thesis in a single sentence contains a reference to both types of knowledge: *"this thesis describes how students learning collaboratively use episodes (a case) to refine existing and acquire new conceptual knowledge*". While the emphasis of the description of learning is certainly on the acquisition and refinement of conceptual knowledge, the basic mechanism proposed is the same as one where a set of information (an episode) is transformed into a meaningful story, and, through this process, knowledge is acquired that is used to interpret similar cases. To introduce the mechanisms of learning from cases, a description of episodes and conceptual knowledge is thus essential.

3.2.3.1 Episodes

The use of this term requires some clarification. Episodes are normally defined as remembrances about events experienced personally. For example, the memory of a birthday party would be an episode. However, the research programmes centred on case-based-reasoning (CBR) and its derivates have extended the meaning of episode. An episode is, according to this

extended definition, a set of information acquired during problem solving that includes the solution. This definition overlaps partially with some of the characteristics of experiential knowledge (Jonassen, 2006). An episode consists of un-interpreted as well as interpreted problem elements, i.e. of 'raw', perceptual problem features, and occasionally some structural knowledge. The definition of what is an episode becomes clearer when considered from the point of view of learning: learning occurs through reuse of episodes and the acquisition of structural knowledge from that reuse. In Gentner's (1989) words: "*every reuse of a stored episode slightly highlights common structural features and contributes to the abstraction of perceptual details*". Following from this definition of learning from episodes, an episode may be best defined as "experiential knowledge memorised as an unstructured set of information needing to be structured".

The use of the term episode is extended here to include, beyond a more or less structured memorised set of information, the case used as the learning material. The above offered definition does apply to cases: cases are a set of information that students are required to understand, that are to be the basis for the use of conceptual knowledge, wherefrom students may acquire structural and conceptual knowledge that they should memorise so that they are reusable in future problem solving situations.

3.2.3.2 Conceptual knowledge

Conceptual knowledge is general knowledge that is used to classify, understand and reason about objects and events in the real world. For example, basic-level categories that represent instances that share perceptual and functional features of objects are conceptual knowledge. Concepts of this kind are called concrete concepts. People use for understanding, classification and reasoning also so-called abstract concepts that refer to non-concrete things in the real world, and do not represent these things in terms of perceptual or functional properties. Examples of abstract concepts are 'good', 'freedom', 'beauty', 'anger', etc. All concepts used to understand and reason about situations of medical ethics and law are abstract concepts. The emphasis of this presentation will hence focus on them.

In contrast to basic-level concepts, abstract concepts derive their meaning almost exclusively from relations to other concepts that rely on yet other concepts for their meaning. For example, the concept of 'good' would be defined, if used in terms of ethical behaviour, through the concepts of 'empathy', 'moral', 'conscientious' etc. that in turn would be defined by other intangible concepts. A special case of relation is the relation of 'contrast' or 'opposite'. An abstract concept may be partially defined through this relation to its opposite. For example, pupils can be taught the concept of 'good' if they have knowledge about the concept of 'bad'.

Clearly, learning about one concept A in terms of the contrast to concept B affects knowledge about concept B since it is also related to concept A. The contrast with concrete concepts becomes evident when it is considered that, though such concepts (e.g. 'apple') are also defined by other concepts (e.g. 'round'), these defining concepts have a perceptual or functional referent in the real world. How intangible concepts are retrieved, used and learned will be discussed in section 3.3.5.

3.2.3.3 Conceptual knowledge: its role in instance models

While research on instance-based cognition (see section 3.2.6) has reduced the importance of conceptual knowledge in cognition, it still has a function in instance-based models. Specifically, the role of conceptual knowledge is to represent the problem in structural terms at the stage of encoding (see section 3.2.6.2), to represent partially the problem episode in memory, and to adapt the past solution to the current problem. These three functions have mostly been identified by research on expertise. This research found that expertise is characterised by a large and well-organised set of typical problems available to be used to solve current problems (see section 3.2.4). Conceptual knowledge affects how these instances are organised, found and used. The importance of conceptual knowledge becomes clearer when it is considered that the most useful past episode must be found in memory, and that problems where similar concepts apply are more useful than others. As research on the organisation of memory has shown, episodes are organised under specific labels and such labels are often constituted by conceptual knowledge (Kolodner, 1993). The representation of the current problem (at the stage of encoding, see section 3.2.6.2) in terms of conceptual knowledge provides hence an appropriate cue for the searching for useful past problems. In terms of representations, conceptual knowledge is hence useful to encode current problems and to organise past problem solving episodes. When a past problem is found, its solution can be adapted to the current problem by using conceptual knowledge: conceptual knowledge tells the problem solver how to adapt the past solution to the problem (Ross, 1987). This role of conceptual knowledge will be discussed in section 3.3.4.4.

3.2.4 The structure of problem solving knowledge

The role of memorised problem solving episodes as the basis to solve current problems opens the question how episodes are organised in memory and how they are retrieved. Several studies that have addressed this problem relied on differences in problem solving of novices and experts. These differences will be described now shortly.

3.2.4.1 Novice – expert differences

Research into the differences in problem solving in novices and experts distinguishes between the stage of encoding and the stage of actual problem solving. In the stage of encoding, people formulate a representation of the problem that provides the cues for the retrieval of an appropriate past episode from memory. There are intermediate stages between these two, but for the purpose of this discussion, the first and the last are the most relevant.

A consistent difference between experts and novices is the kind of representation made at the stage of encoding. Novices focus on surface features, while experts are able to discern structural features in the problem description. For example, in describing a physics problem, novices focus on perceptual features (e.g. 'inclined plane'), while experts would describe the problem in terms of abstract concepts such as energy or force. A second difference is that experts would then apply a forward strategy and try to confirm whether their initial conceptualisation of the problem is correct (cf. Patel & Groen, 1986). Novices instead adopt a backward strategy and would try to find an appropriate formula or concept that could be applied to the surface features. A third important difference in expert vs. novice encoding is the use of categories and the type of categories used: classification of problems typical for experts (such as "this is an energy-conservation problem") is either uncommon in novices or, again, based on surface features ("this is an inclined-plane problem") (Chi, Feltovich & Glaser, 1981).

These findings have been used to emphasise the importance of problem-, case- and example-based learning, because they show that in order to become organised, knowledge needs to be applied to concrete problems. Some models have been developed that show that a reorganisation of existing knowledge through practice can account for several of the expert-novice differences, including differences in strategy (Elio & Scharf, 1990).

3.2.4.2 Problem solution schemas and conceptual systems

The superior problem solving performance of experts has been related to a better organisation of existing knowledge. The core organisational unit of experts is a problem prototype or problem schema (Chi et al., 1981; Rumelhart, 1980). This organisation must be described at two levels: first the organisation within or of a schema, and second the organisation between schemas.

Expert problem schemas are different from novice schemas in that they contain specific knowledge about the applicability of the schema. Novice schemas are in reality only very generic problem-solution schemas that are invoked by a much larger range of problems than expert schemas. Expert schemas also contain specific solution procedures, as opposed to general problem solving strategies that novices must rely on.

For the purpose of this discussion, the most important feature of expertise is the relation between schemas and their relation to conceptual knowledge. As has been described, experts are able to quickly classify a problem in terms of medium- or high-level principles or concepts. Classification relies on domain-specific conceptual knowledge. This conceptual knowledge is, in experts, a highly interrelated conceptual system that, once invoked, can be used to attempt alternative representations of the problem. The activation of one concept in that system activates concepts associated with it, and hence the expert can access concepts independently of the specific features of the problem. The conceptual system is, in a sense, knowledge that is to a degree independent from specific concrete features of the world. Though novices have also knowledge about concepts, these concepts are less interrelated. Instead, novices may have merely associated a concept with a specific surface feature that provides the activation cue for the concept (see figures 4 and 5 in Chi et al., 1981). Once classified through this association, the novice is, due to the absence of relations between concepts, unable to use alternative concepts.

3.2.5 Problem solving: approaches and assumptions

3.2.5.1 Introduction

The following sections present views on problem solving and discuss some notions pertinent for the analysis and interpretation of the dialogue data. Current research distinguishes three forms of problem solving: using previous episodes, using problem schemata and using a domain model or theory. Most research of the last 3 decades has viewed problem solving as the reuse of earlier problem solving episodes. This research is based on an approach in cognitive science termed the instance view (cf. Medin & Ross, 1989). Though the use of earlier episodes in problem solving is clearly evident when students use spontaneously textbook examples or are prompted to do so, the instance view assumes that episodes play a significant role in cognition even if people apparently rely on general knowledge. This view has informed the analysis as well as the specification of the learning goals in the thesis, and will be given major prominence. The schema view of problem solving is a specialisation of the instance view: problem schemata are 'generic instances' that represent a class of similar problems. This form of problem solving is typical for experts, and schemata are acquired through experience. The last view assumes that people sometimes solve problems by applying a generic domain model or domain theory. This view is given some attention here because students have their own mundane model of ethics, and employ it when discussing the cases. The peculiarity of this form of problem solving is that instead of relying on the problem features to activate concepts, concepts are activated by other concepts, and problem solving is the attempt to apply a conceptual system on the case.

The instance view of problem solving has influenced how traditional issues related to problem solving are seen. For example, it has re-evaluated the role of conceptual knowledge in problem solving, it has described the differences in problem solving strategies in terms of content knowledge, and it has emphasised the role of memory in problem solving. These three issues will be discussed next sections. The first section will discuss a fundamental assumption of the instance view, namely that cognition in general and problem solving in particular rely on the retrieval of particular knowledge (schemata, memorised instances and interrelated concepts) units from memory. The next section will present the assumption that problem solving relies on the activation of knowledge units that is largely automatic. This assumption is generalised to encompass the retrieval of conceptual systems, such as a small domain model. The subsequent section introduces the notion of adaptation that further highlights the role of conceptual knowledge in the instance view.

3.2.5.2 Arguments for and evidence of instance-based problem solving

That past problem solving episodes are used for solving current problems has been supported initially mostly by arguments. Recently, however, several studies have shown that several cognitive processes indeed use instances. Here, evidence and arguments of the use of previous episodes are shortly described.

The role of instances in problem solving and learning can be understood within the question raised by Winston (1980): what information guides generalization and induction from examples? If not constraint by knowledge, these learning processes would operate undirected over examples and thus the acquisition of abstract or general knowledge is impossible (cf. Van Lehn, 1987). Past examples, stored in memory and retrieved when needed, or examples that can be inspected in a textbook during learning provide powerful constraints on generalization and induction; and thus, learning is possible.

Evidence of the use of earlier episodes in solving real-world problems has been collected through field studies. A major study with high ecological value was Klein & Calderwood's (1988) interviews of experienced emergency managers. They found that expert fire fighters made extensive references to and drew similarities with earlier problem solving episodes. As will be discussed later in detail, such knowledge becomes especially important if codified knowledge is unavailable or if the problem is particularly complex.

Several laboratory studies have also investigated the role of examples in problem solving. For example, in Anderson's study on LISP programming (Anderson, Farrell & Sauers, 1984), students were not able to solve examples unless they referred to previously solved ones. The

authors claim that looking back helped the students to understand better abstract principles. It has also been found that even if an abstract principle or formula is provided with a problem, students have difficulty to apply it (Ross, 1987). An earlier example would provide the necessary information on how to instantiate abstract formulae. Ross & Kennedy (1990) ascertained the influence of earlier example use through a 1 training – 2 tests experimental procedure using the cuing paradigm. In this paradigm, subjects are prompted to use an earlier example, and the reuse occurs under controlled conditions. The study showed that students prompted to use the training example to solve the first test example, improved performance in solving the second test example.

Previously solved examples aid students in two significant ways (Reimann & Schult, 1996): first, examples help students with the interpretation problem. To solve a problem, students need to relate the problem description to theoretical concepts of the domain. For example, a pulley problem in physics may need to be understood in terms of forces and masses. Previous examples here show how to get from problem descriptions to theoretical reformulations. Second, earlier examples provide knowledge about when and how to apply a specific solution step. Ross (1987) found that students indeed use earlier examples to help them instantiate correctly an abstract formula. This problem, also called the control problem, arises because using general problem solving rules or heuristics is computationally prohibitive and cognitively demanding (Cooper & Sweller, 1987), as some amount of planning is required for problem solving in the absence of familiarity with the solution. Examples constitute, in a sense, minimal solutions, containing specific steps and specific information about the applicability of a solution.

3.2.5.3 The role of cuing and activation in problem solving

A general assumption of instance-based models of problem solving is that when people are confronted with a new problem situation, they retrieve knowledge units from memory, such as memorised episodes or concepts. This assumption relies on the psychological concept of cuing: exposure to a stimulus prompts the retrieval of knowledge entities related (associatively or through labelled relations) to it. Further, since knowledge entities in memory are related to other entities the activation of a knowledge entity may prompt the activation of those related to it, a phenomenon known as 'spreading activation' (Anderson, 1976; Ratcliff & McKoon, 1988). This spread may activate knowledge entities that are semantically or associatively related to the first activated unit, and hence to the stimulus. This accounts for the activation of conceptual knowledge from problem features, as well as the activation of concepts that are related to other concepts.

For the purpose of this discussion, it is important to emphasise that the notion of activation entails that the retrieval of knowledge during problem solving maintains a character of automaticity. This character has implications for models of problem solving and learning. It entails that when people are confronted with a problem situations, knowledge units are retrieved because they are related to the stimulus and because they are related to other knowledge units. The relations can be associative or labelled relation; or the activation may occur on the basis of structural or surface similarities.

The research on expertise cited earlier (section 3.2.4.1), has confirmed the role of activation of knowledge. For example, it has shown that experts retrieve, based on an initial encoding of the situation, problem-solution schemas that contain procedural knowledge about the solution of a problem. The retrieval of memorised episodes is based on a feature-matching process: the initial representation of a problem (see section on encoding 3.2.6.2) sets up cues that probe into memory and retrieve instances whose representation matches with the cues. The research on expertise has also confirmed that experts are able to access conceptual knowledge from other conceptual knowledge related to it.

Research on instance-based problem solving has shown that the first knowledge units activated by the problem description are either superficially (in novices) or structurally (in experts) similar to the problem description. The difficulties of analogical retrieval are in some models explained as interference from surface similarities (Forbus, Gentner & Law, 1994), a clear example of the influence of stimulus similarities on problem solving. It has also been found that what knowledge is initially activated has a strong impact on how the problem is solved and what is learned (Ross, Perkins & Tenpenny, 1990). This issue will be discussed later in the section on reminding (section 3.2.6).

For the purpose of this thesis, the notions of cuing and activation are the basis of an analysis targeting the students' knowledge structure. Specifically, based on these notions, the description of a case and the use of a specific type of knowledge in discussing cases can reveal the structure of knowledge of the students (see the episode-focus analysis, section 6.4).

3.2.6 Episode-based problem solving: encoding and adaptation

3.2.6.1 Introduction

The following sections introduce now two of the stages of the generic model of problem solving from past episodes, the stage of encoding and the stage of adaptation. The whole process of episode-based problem solving includes two more stages – memory access and retrieval – or

one or two other, depending on the specificity of the model. The stages described here are however the ones most important for the analysis and interpretation of the data.

The stage of encoding is the initial stage of processing a problem that results in the description of the problem. The stage of adaptation occurs once a similar past episode is found in memory and its solution is to be transferred and adapted to the current problem. The stage of adaptation is given emphasis here because interpretations of memorised cases can be useful to interpret current ones. The adaptation of an earlier interpretation occurs through similar mechanisms as the adaptation of solutions. The learning material used in study 3 (section 8.4) involves solutions intended in a traditional sense.

3.2.6.2 Two stages of episode-based problem solving: encoding and adaptation

Encoding

When confronted with a problem, people encode it, i.e. they provide an (unconscious) description of it. Encoding occurs spontaneously and has been likened to a perceptual process (Chase & Simon, 1973). Encoding of a problem situation is crucial for finding a solution because this stage furnishes the cues used to probe into memory. As emphasised earlier, novices' inability to encode problems in structural (deep) features accounts for their inferior problem solving performance. In this section, encoding is described in detail by focussing on the differences and specificities of description made by novices, intermediates and experts, and on what knowledge is used for these descriptions.

The distinction between novice and expert encoding is that novices emphasise surface features and perceptual aspects of the problem while experts are able to see beyond them and use structural and conceptual knowledge for descriptions. Experts' type of encoding is also called qualitative encoding. Qualitative encoding manifests itself not only in different descriptions, but also in how the surface aspects of the problem are seen. Specifically, experts are able to see more quickly and more correctly whether aspects are relevant or irrelevant for solutions or interpretations. For example, experts in medicine can distinguish quickly whether a symptom is alarming or not (Patel, Groen & Norman, 1991). Another important aspect of expert encoding is the ability to assign specific roles (if the problem requires) to aspects. For example, expert chess players assign their and their opponent's pieces roles in accordance with the overall configuration on the boards (e.g. 'pawn attacking queen'; Chase & Simon, 1973). It should be pointed out that the assignment of relevance and the assignment of a role to the aspects occur before a solution is proposed. In this sense, encoding is deemed to be perceptual. In the analysis

of the data, the assignment of relevance and of a role will be used both as an indication of the students' existing knowledge, and of their learning progress during the discussion.

The representation of problem solving knowledge described in section 3.2.4 and the notion of activation described in section 3.2.5.3 converge onto the conceptual encoding observed in experts. When solving problems, experts rely on a quick classification of the problem. This initial classification activates a set of associated concepts that can be used to support the initial classification, elaborate some of its details or attempt an alternative one.

Adaptation

Adapting a previous solution or interpretation to a case or problem is the last stage in episode-based problem solving. Its significance for learning is that, in order to adapt a previous solution, the similarity between elements of the past and the current problem must be identified. Abstraction of properties common to elements of both situations (the past and the current) is necessary in order to find a match (Winston, 1980). For example, if the solution consists of a formula with variables, then it needs to be identified which concrete elements (e.g. values) of the current situation are to be inserted into the formula. The identification of the appropriate concrete elements occurs through a similarity assessment that may use conceptual or structural knowledge or a class for identification. During this stage, significant learning can occur.

The reuse of previous solutions or a previous interpretative structure is often conceptualised under the phenomenon of transfer. Though the concept has been strongly criticised by some authors (Lave, 1988), it remains of foremost importance to conceptualise learning. The efficacy of formal education (such as classroom education) is critically dependent on the ability of students to transfer earlier acquired structural knowledge to situations in the real world.

Several studies have investigated how to improve the transferability of structural knowledge and have identified which knowledge is most likely to improve transfer. This is knowledge about the applicability of earlier solutions and knowledge about the applicability of concepts (cf. Singley & Anderson, 1989). Both these forms of knowledge are acquired through problem- or case-centred learning. The exposure to a series of structurally similar problems fosters the acquisition of general knowledge about when and how to apply concepts and procedures. Learning of these forms of knowledge will be discussed in section 3.3.4.

3.2.7 Summary

The phenomena of problem solving presented in the previous sections point to one conclusion: problem solving depends on content knowledge, memorised episodes and problem schemata, rather than domain-independent general rules. How these knowledge structures are acquired is discussed in the following sections on learning.

3.3 Learning

3.3.1 Introduction

The following sections will present research findings that have focussed on how these knowledge structures are acquired, i.e. on learning. With the shift to view problem solving proficiency as being dependent on content knowledge, research on learning has focused on how problem schemas, conceptual systems and other knowledge structures are acquired during learning. There is substantial agreement that these knowledge structures are best acquired during problem solving, and when studying examples or cases.

The description of learning presented in the following sections will be mostly based on cognitive science research. The first section will locate the models of learning from problem solving within a larger framework of models of learning. It will be argued that the instance view can explain several phenomena of learning normally described outside the instance view. The second section reports evidence of the proficiency of educational curricula that employ significantly or exclusively problems, examples or cases as learning material, such as PBL (problem-based-learning, Barrows, 1988). The subsequent sections will introduce generic mechanisms of learning from examples or problems, and describe extant models of problem- or case-centred learning. The next section focuses on two specific learning processes, learning from comparisons and learning by employing a conceptual structure. The section is concluded with an overview of the learning processes that will be used bases for analysing and interpreting learners' dialogues.

3.3.2 The educational value of learning with problems

The current view on the role of problems in learning can be traced to the importance of the 'problematic' or the 'challenging' that philosophers such as Dewey or psychologists such as Piaget have attributed to learning (cf. Savery & Duffy, 1996). Solving problems means implicitly testing out one's knowledge, and failures to solve a problem will entail a revision and modification of that knowledge. Piaget's contribution to this view is in his notion of accommodation (cf. Piaget, 1977): when current experience cannot be assimilated into existing knowledge structures, these structures need to change so that they can accommodate the new experience. This general view has, more recently, been embraced by developments in education, some, as will be described later, based on or spawning models of cognition. For example, Schank (1983) proposed to teach through stories that would challenge traditional narratives, and based it on a cognitive model of problem solving through story retrieval. His proposal

emphasised the importance of locating abstract to-be-acquired knowledge within an authentic context, and hypothesised that the context would furnish additional cues for the retrieval of appropriate knowledge required in future problem solving situations. Similarly, several other authors have proposed to place students into learning environments that are 'authentic' (Honebein, Duffy & Fishman, 1993; Bereiter, 1994) in the sense that they present the same 'type' of cognitive challenges than do real world environments. Following these prescriptions, students learning science, for example, should participate in scientific activities that would engage the student in scientific discourse and problem solving.

A recent development in education, problem-based learning (Barrows, 1985), has led to a revision and re-structuring of basic curricula, especially in medicine, but also law and business. A few universities offer now, exclusively or in parallel with "traditional" curricula (TC), a curriculum where learning is centred exclusively on problems, such as clinical problems and cases (Albanese & Mitchell, 1993). Traditional curricula, instead, focus on teaching basic theoretical knowledge (such as biomedical concepts) first; students would apply that knowledge only in their 4^{th} or 5^{th} year of study.

Research on the efficacy of PBL allows some insight into the effect of problems on knowledge and specifically in what kind of knowledge problem-based learning generates. There is some agreements that the overall efficacy of a PBL versus a traditional curriculum is not greater, though studies addressing this issue suffer from some methodological problems such as their longitudinal nature or the voluntary participation of students. However, some differences in the mode of problem solving have been observed and differences on the structure of knowledge can be inferred. PBL-taught second-year students use a distinct mode of reasoning as opposed to TC-taught students, and specifically hypothetico-deductive reasoning (Patel, Groen & Norman, 1991). These students, when faced with a new clinical situation, formulate more hypotheses than TC-taught students, and do not base their analysis on single symptoms. While they possess less basic biomedical knowledge, they are more able to apply biomedical knowledge correctly to a clinical situation. TC students, instead, possess a larger knowledge base of abstract concepts, but are unable to apply them. These results point to the conclusion that when learning with problems students learn about the applicability of conceptual knowledge that allows them to retrieve the appropriate concept with the appropriate clinical situation. In simple terms, while TC students possess more basic biomedical knowledge, PBL students possess less but know how to use it. Indeed, also their explanations are more likely to incorporate biomedical knowledge, than the explanations of TC students (Patel, Groen & Norman, 1991). Two main explanations have been offered for this effect of PBL: first, applying conceptual knowledge to concrete cases or problem furnishes that knowledge which is essential for generating organic knowledge structures that incorporate specific situations as well as abstract knowledge; and

second, the acquisition of examples during problem solving may mean that a later problem is solved on the basis of similarity (Brooks, Norman & Allen, 1991). Reuse of earlier problem entails comparisons between problems and promotes the acquisition of domain-specific problem types (categories). The literature on PBL is of particular interest because of its high ecological validity, and the findings of differences in the integration of conceptual and episodic knowledge confirm the prediction of models developed on studies of expertise.

3.3.3 Learning from one example

The practice of learning from one example is widespread. Teachers use routinely examples in traditional classroom settings to illustrate the application of procedures, concepts or conceptual systems. Problem- and case-based learning can also be considered a form of learning from one example since no conscious effort is made to structure the problems or cases employed throughout a curriculum to make them conform to a cognitive model of learning from multiple examples. Rather, a case or problem is used so that students learn specific conceptual knowledge, not that they learn from similarities between the cases.

However, these learning situations occur normally with the presence of a teacher, tutor or facilitator that is able to guide the learning process. As VanLehn has argued, learning from one example without such guidance may be too unconstraint and hence impossible (VanLehn, 1987). Specifically, students would not know what to generalise from a single example (induction problem) or what conceptual knowledge to apply to an example.

Models of learning from one example presuppose that general knowledge acquired from problem solving is modified only by further examples that implicitly function as tests of that general knowledge. For example, Van Lehn (1986) describes learning as an induction process: when learning simple arithmetic, students generalize a formula, such as how to subtract and borrow from a 0 position. When solving further examples, the formula is applied and errors, such as overgeneralization or overspecialisation, occur. These errors lead then to a revision of the formula. The important aspect of his model is that examples studied earlier do not directly influence learning because they are not used to constrain or guide the application of the formula.

The case-based and project-based learning approach assumes that learning from one case is possible if the indexing of the case is sufficiently guided by a tutor or constraint by the available indexing vocabulary (Guzdial et al., 1997; Ward, 1998). In this latter variation, students would be given a list of terms, normally qualitative and domain-specific ones, and asked to select those that characterise best the case, problem or project. The selected terms constitute then the indices, i.e. the features that represent the point or story of the case or problem. When confronted with a new problem, students would first be asked to describe the problem in these

terms, and then use this description as cues for the retrieval of similarly indexed solved problems. This form of project- and problem-based learning proposes to make the encoding and memorisation stage explicit, and hence promotes generalisations of indices and the construction of a domain-specific concept map.

Another form of learning from a single example is learning from worked-out examples. Worked-out examples present an example or problem together with a solution or interpretation provided by an expert problem solver. In order to maximise learning gains, the solution is not presented contiguously with the problem, but is given to the student only after s/he has proposed her own solution or interpretation (Redmond & Phillips, 1997). A phased presentation of expert solutions may also be used in order to reduce the cognitive load of the student. The educational model supporting this form of learning rests on the assumption that students will try to modify their knowledge when they become aware that their solution or interpretation proposals are insufficient. While such awareness may quite easily occur when the student has difficulties to solve the problem (or fails), the availability of an expert solution permits the student to locate with more precision what knowledge is deficient. The student's own concrete solution proposal plays hence a critical role: it permits the student to identify specifically the difference in her and the expert's knowledge.

A last form of learning from one example is explanation-based learning. This learning occurs when students apply conceptual knowledge to an example. Its precondition is that students have at least some theoretical knowledge of the domain, that is, they have knowledge about some basic concepts and about relations between concepts. The difference between this form of learning and a traditional empirical form of learning (i.e. one arising from the presentation of several positive and negative instances) is that it leads to the acquisition of general knowledge by identifying problem aspects that can be explained by the domain theory (Mooney, 1993). Specifically, if an example can be partially explained, then the features partaking in that explanation are added to the general definition of the concept. This mechanism is best described in terms of structure. A domain theory is composed of concepts and relations between them. Relations can be causal, hierarchical, semantic, or merely associative. Among others, causal relations provide explanations: when two aspects of a problem are related causally, one aspect is explained as being the cause of another aspect. This is equivalent to imposing a structure on the example: it relates aspects and assigns aspects a role ('the cause' and 'the effect').

This concludes the overview of extant models and practices of learning from one example, problem or case. The differences between this form of learning and learning from multiple examples are the following: learning from one example takes advantage of existing domain

knowledge, and reduces the need for the study of or exposition to large sets of examples. Learning from multiple examples also generates different knowledge: the core mechanisms of learning from multiple examples are feature abstraction through similarity and generalisation over features resulting from the reuse of previous solutions. These mechanisms will be described now in detail.

3.3.4 Learning from multiple examples

3.3.4.1 Introduction

This form of learning is recognised as the core learning mechanism for the acquisition of problem schemata, the most efficient knowledge representations for solving problems in knowledge-rich domains (Cooper & Sweller, 1987). There is consensus that "problem-type schemata are acquired through some inductive or generalisation process involving comparisons among similar or analogous problems of one type" (Bernardo, 1994).

In discussing these models, an initial distinction must be made between the prompted (cued) and spontaneous use of previous examples. There is much observational evidence that novices are inclined to 'look back' to earlier solved examples, but it is also a common though informal tutoring practice to explicitly prompt students to do so. In a sense, learning from reuse occurs frequently in the classroom (though, as will be outlined shortly, not in an ideal manner).

The mechanism of learning from multiple examples is similar whether the reuse is prompted or spontaneous: both require a solved problem, whether it is in external memory (e.g. a text book) or in long-term memory. Spontaneous and implicit reuse, however, assumes that earlier problem solutions are memorised at least partially together with their solutions, an assumption that has been debated extensively in research. This is discussed in short now.

3.3.4.2 The retention of instances

Early views of cognition assumed that several high-level cognitive processes are based on the retention and reuse of instance. Analogies and metaphors were assumed to be core mechanisms of problem solving and learning (cf. Orthony, 1978). In the last two decades these processes have been investigated in detail (Gentner, 1989) and modelled (Forbus, Gentner & Law, 1994; Anderson & Thompson, 1989).

Early models of learning from examples focused on the general knowledge that is acquired by solving problems, being exposed to several instances of the same category or, in an educational context, studying with examples. Since it is general knowledge that is important for future

categorisation or problem solving, it is assumed that instances are discarded, an assumption argumentatively supported by the principle of cognitive economy. However, several recent studies have shown that despite learning processes occurring over instances – such as generalisation or induction – instances may also be retained (cf. Reeves & Weisberg, 1994). Retention and use of instances has obvious benefits if it is considered that, in early stages of learning in a domain, general knowledge induced from only a few examples is still be too inaccurate to be useful. Stored instances would serve as bases for comparison and reuse of known solutions (cf. Ross, Perkins & Tenpenny, 1990). At higher levels of competency, general knowledge is able to capture most positive instances, but instances are nevertheless retained if they are particular or notable. The argument of cognitive economy is weakened by research that showed human memory has a high capacity, and that the lack of retrieval of specific instances is not due lack of memorisation or to memory loss, but rather to ineffective search. Finding instances does indeed require more specific cues because they are often retained together with several contextual elements (encoding specificity; Smith, Glenberg & Bjork, 1978). A condition for the psychological possibility of episode-based problem solving is therefore given: episodes are retained even if they have contributed to the construction of general knowledge.

3.3.4.3 Processes and products of instance-based learning

There is much evidence of the usefulness of looking back at previous examples to solve current ones. For example, in Anderson's study on LISP programming (Anderson, Farrel & Sauers, 1984), students were not able to solve examples unless they referred to previously solved ones. Further, the studies of Chi and colleagues on expertise (Chi, Feltovich & Glaser, 1981; Chi, Glaser & Rees, 1982) have permitted a good insight into the differences in knowledge structures of experts and novices, and that research has spawned further research into how these knowledge structures are acquired. As mentioned, there is consensus that the exposition to several problems and the reuse of earlier problem solutions are the foundations for the acquisition of expertise. This research has been conducted mostly under the labels of experiential and analogical learning. It is reviewed now.

The peculiarity of learning from 2 or more examples is most evident when it is considered that what is learned in this way may be very different from the surface features of the examples involved (cf. Ross & Kennedy, 1990), and it is this aspect of learning from 2 examples that most distinguishes it from learning with 1 example. In most models of learning from 1 example another example just adds another surface feature accepted as input for the applicability of a schema (slot) or rule (in its condition part) or modifies an overgeneralized condition part

through specialization (cf. Van Lehn, 1987). By reusing earlier problem solutions, what is acquired is actually general knowledge. In fact, in order to reuse an earlier solution to solve a current one, problem solvers must generalize over the surface features of the two examples. That is, they must recognize some similarities between the surface features and by doing so they may acquire general knowledge.

Learning from two or more examples could occur at several stages of reuse: at the access/retrieval stage, at the mapping stage and at the transfer stage. All of these stages require abstraction in order to make comparisons to identify correspondences. There is still little work addressing specifically the locus of learning (an exception being Ross & Kennedy, 1990). The question of when, i.e. at what stage, learning occurs is important because different knowledge may be acquired at different stages.

One of the first and most radical models of instance-based problem solving and learning is the case-based-reasoning (e.g. Aamodt & Plaza, 1994; Kolodner, 1993). CBR makes the following assumptions about the representation of knowledge, problem solving and learning: knowledge is represented as a set of previous problem solving episodes (called cases) that are stored in a hierarchically organised knowledge base. Concise representations of an episode (called labels or indices) representing the cases' structural features (their 'point' or 'story') organise the cases. Cases with similar indices are stored under the same header with indices of difference representing the specificity of each of the cases. Problem solving is, according to the CBR model, simply retrieval of the most similar case from the knowledge base, and adaptation of its solution to the current problem. The most significant issues CBR research relate to the indexing problem (i.e. which indices best represent the usefulness of the case for future problems).

Learning from multiple examples can also result in schema abstraction (Gick & Holyoak, 1983), the 'bootstrapping of the structure common to the base and the target'. Learning occurring when solving Duncker's radiation problem cited earlier (section 3.2.4) is modelled as a form of schema abstraction. This and other similar model embrace the view that episode-based reasoning processes require comparisons between the base and the target example that can result in the extraction of commonalties. A schema is seen, according to this general model, a special form of commonality, specifically a set of coherently organised relational commonalties.

The instance view of learning distinguishes hence two forms of learning from cases: first, studied cases are added to the knowledge base. And second, when memorised cases are used in other problem solving situations, learning processes occur during reuse, through processes associated with analogical problem solving. In light of the relevance of previous instances for

learning, it is now important to synthesise the role of instances *and* general knowledge in learning. This is the topic of the next section.

3.3.4.4 The use of general and instance-specific knowledge in problem solving

Though pure instance models have been proposed, the currently most prevalent model is a hybrid model where both general as well as instance-specific knowledge is used (Ross, Perkins & Tenpenny, 1990). It has been shown, for example, that applying general knowledge to a new problem is often more difficult than retrieving a problem example that has been solved and reusing it (Ross & Kennedy, 1990). Previous examples or problems would, in this case, be used together with general knowledge (such as a formula or procedure) to aid the instantiation of the new problem and permit the use of the formula or procedure.

Hybrid models derive their strongest support from the fact that to locate the most useful past solution is difficult or impossible given that novel problems are encoded in surface features (see section 3.2.6.2), and surface features are not indicative of the structure of the problem. Memorised examples are stored in both their surface and structural features, and again there is no relation between them that would allow the inference from surface to structural features. Indeed, general knowledge may be more similar to the current problem than a specific past problem. As a consequence, a search based on surface features will retrieve none or only inadequate past examples. General knowledge, however, can provide at least some encoding of the current problem and thus narrow the set of possible candidates.

3.3.5 Conceptual learning

3.3.5.1 Introduction

The following subsection describe how conceptual learning can occur without the processes typically associated with episode-based problem solving, i.e. comparisons, schema abstraction and feature abstraction. This special form of learning is necessary in order to account for the possibility that students discussing cases rely on a mundane model or mundane domain theory of ethics or medical law. The use of this type of knowledge engenders different processes and different products. Specifically, learning about the applicability of concepts and relating concepts are the main learning mechanisms that occur in this situation: knowledge about the applicability of concepts is acquired and this knowledge becomes part of the condition part of a

concept representation. Another major form of learning is relationing concepts. This form of learning is especially furthered through cases because cases, describing a set of event, actors, relations between them, etc. are likely to foster the application of several concepts. This in turn promotes reflection about the relations between concepts. The educational value of case-centred learning described in chapter 2 is most evident in these forms of learning: students learn to integrate concepts with concepts, and aspects with concepts.

The description of conceptual learning opens with a general overview of conceptual learning, and discussion on the difficulties to model it. The section also describes those general properties of concepts that are relevant to understand how concepts are learned. The focus of this section is on abstract concepts. A next section introduces the notion of conceptual change that is recognised as being one of the most powerful and valuable phenomena of learning. The last section describes two mechanisms of conceptual learning in detail.

3.3.5.2 The structure of concepts

Learning and teaching abstract, intangible concepts such as those employed to discuss cases of medical ethics, provides a particular challenge for students and teachers. Specific and detailed educational programs or psychological/educational models of the acquisition of such knowledge are rare. Teaching conceptual knowledge is normally closely linked with the traditional mode of education: a teacher in front of the class using a backboard for summary or exemplification. With the criticisms this form of education has experienced in the last decades, the interest in such models is low. Instead, several models have been developed to describe how conceptual knowledge is acquired from studying examples, problems or cases. These models concur in the assumption that studying examples implies the use and test of existing conceptual knowledge; if found inadequate for explaining or solving an example or problem, new conceptual knowledge is acquired or existing one modified. This view has led to a major interest in the role of misconceptions for learning, and in learning as the development of more expert domain-specific knowledge from mundane knowledge.

However, while significant progress has been made in describing learning in domains of 'hard' science, such as physics, the mechanisms of learning conceptual knowledge in other domains, such as social sciences or ethics, are less specified. The difficulty of describing learning in these domains derives in part from the difficulty of defining the concepts and to operationalize the acquisition of meaning. For example, with regard to ethics, a specific description of learning more expert ethical concepts from mundane concepts is rendered difficult because no detailed research on mundane ethical knowledge usable for the present discussion exists.

The descriptions of learning mechanisms in this chapter will therefore rely to large extend on general structural properties of concepts and generic models of concept and category learning. Specifically, conceptual learning will be described as the acquisition of knowledge about the applicability of a concept, and as the acquisition of a domain-specific conceptual system (intended as a set of concepts and their relations).

As already described in section 3.2.3.2, a distinction is made between concrete (basic-level) categories and abstract categories. These latter do not represent objects in terms of perceptual and function features. Research on learning scientific concepts in the domain of physics (the domain mostly used in studies on the acquisition of scientific knowledge) may be most representative to model the acquisition of abstract concepts in different domains.

Models of learning scientific concepts of physics emphasise that learning should be described as 'understanding the relationships between concepts' and 'understanding the interactions between elements of the physical world'. Conceptual knowledge about physics is highly interrelated (cf. Chi et al., 1981). If applied to a specific physics problem, the conceptualisation captures the interaction between the elements of the problem. It is no surprise then that the most promising models of scientific concept acquisition rely strongly on learning from and with analogies and metaphors. Indeed, complex interactions may be best learned on the basis of simple interactions (e.g. Podolefsky & Finkelstein, 2006; Newby, Ertmer & Stepich, 1995, Forbus & Gentner, 1986) of which people have structural knowledge due to their everyday experiences (cf. Lakoff, 1990).

From this description of the structure of intangible concepts, two general mechanisms of learning can be deduced. First, the assumption that the meaning of concepts is partially defined by their relations to other concepts allows evidencing the acquisition of new meanings of concepts. It would happen, for example, when a concept is acquired through a similarity statement or a differentiation with other concepts. Learning the interrelations between concepts and learning how and when concepts apply contributes significantly to conceptual knowledge. The definition of the meaning of an abstract concept in terms of its relation to other concepts (see section 3.2.3.2) allows, at least to a certain extend, simulating the acquisition of meaning since it is defined in structural terms.

Second, concepts have extensions, i.e. objects or situations where the concept applies. Applicability of a concept to an object or situation is partially determined by feature matching between objects and the condition part of the representation of concepts, and applying a concept to an 'object' entails its instantiation. As will be discussed in detail in the following sections, instances play a significant role in determining the applicability of concepts, because their

concrete features are used to instantiate the abstract knowledge of concepts. Relating an instance to a concept is valuable for learning because the concept is augmented by concrete specific information that is useful for applying it to future instances.

3.3.5.3 Conceptual change: a description

Conceptual change is the phenomenon of quite radical, incisive and sudden reorganisation of conceptual knowledge. The label is applied when people's description or explanation of problem situations differs substantially from their earlier descriptions, and specifically when underlying assumptions are replaced[2] and the same problem aspects are interpreted differently but still coherently.

The view of conceptual change as being an internal reorganisation of knowledge has been adopted by traditional cognitive science. The sudden reorganisation of external percepts has been described already by Gestalt psychology, without however relating it to a change in conceptual knowledge. The dual nature of conceptual change, i.e. it being evident in how people see the external world, but depending on an internal structure is still accepted (e.g. Gick & Holyoak, 1980), but it not strictly necessary. The notion of conceptual change may be used to explain the sudden perceptual reorganisation, including the restructuring of problem situations, without making a commitment to whether that reorganisation entails or is dependent on an internal change[3]. For example, Roschelle (1992) describes the learning of his dyads as conceptual change without however linking that change to a change in conceptual knowledge (see section 2.3.6). The assumption that the perceptual reorganisation related to a conceptual one has been adopted as a result of the assumption that conceptual knowledge provides a basis for the structuring of external situations (see section 3.2.4, especially the references to Chi, Feltovich & Glaser, 1981, on the role of conceptual knowledge in the perception of problem situations). That is, a change in one or more basic concepts and their organisation may affect how a set of similar situations are seen and solved. There remain doubts about the nature of similarity, as well as problems with the notion of transfer of structural knowledge (Lave, 1988).

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[2] It is as yet not clear whether misconceptions are replaced or whether they may still remain active in a modified form (cf. Smith, diSessa & Roschelle, 1993).

[3] Most research on analogy did make that commitment: the abstraction of structural knowledge from a single example or problem entailed also the retention of that structural knowledge. This is necessary for it to be transferred across situations. Lave's (1988) critique of transfer, and many researcher working within the paradigm of situated cognition, question however that entailment. Though they accept that the reorganisation occurs, that novel structure remains welded to the original situation. The reorganisation does not affect nor depend on a basic conceptual system that could affect other situations.

In this thesis, the assumption is maintained that the reorganisation of an external problem situation (or, indeed, a case) is accompanied with a reorganisation of conceptual knowledge. However, no commitment is made whether the reorganisation (or restructuring) of an external object requires a conceptual reorganisation. Rather, in line with Roschelle (1992) the reorganisation of an external object itself is called conceptual change. The clarification is necessary because, as will described in detail in chapter 8, the learning observed in the discussions analysed there may not entail a reorganisation of conceptual knowledge; rather, the students learn how to apply a conceptual system onto the cases, i.e. they restructure only an external object. There are insufficient data to claim that that external restructuring was accompanied or even dependent by an internal one; and indeed, it is very likely that the students did not possess any major misconceptions about the domain, but rather possessed insufficient knowledge about the domain even to produce an initial incorrect conceptualisation. They learning achievement is to be able to see the more expert conceptual system *in* the cases (see also chapter 9 for a more detailed description of this phenomenon).

As a simple example of a reorganisation, pupils may explain the differences in temperature of the seasons (cold – mild – hot – mild) from the incorrect assumption of a curlicue path of the earth around the sun (Davis, 2001). Later, upon hearing that the earth describes a circular path around the sun, a pupil may hypothesise that the earth is tilted, and an alternative explanation for the seasons emerges.

For conceptual change to occur several conditions must be met, of which two are located in people's conceptions. First, misconceptions should allow a coherent – if incorrect – explanation of a problem. Second, people need to hold strong beliefs about their conceptualisations, i.e. they should be satisfied with explanations even if they are, objectively, incorrect. The importance of coherence is central: a coherent explanation, i.e. one that satisfies and is based on several core ideas, gives people a sense of being able to explain a problem. 'Breaking' one assumption may lead to a revision of others.

3.3.5.4 Two mechanisms of conceptual learning

Learning the applicability of concepts

At a most general level, the application of conceptual knowledge to an instance implies a feature matching: features of the example are matched with features of the concept – specifically its condition part – and a high correspondence determines the applicability of the concept. However, some features of the concept and the instance may not find an appropriate match, and learning may occur as a result. In Piaget's theory (e.g. Piaget, 1977), this can lead to a

modification of a schema (accommodation). In very general terms, accommodation is the integration of new information into the schema, i.e. when instance features that find no correspondence with features in the schema are made part of the schema. What is essential for this mechanism to be triggered is the 'perception' of the unity of the example: features of an example must be deemed part of the example. Though this appears to be a truism, it is a crucial requirement: the features of a concept or schema should match possibly to all features of an instance; applicability increases if features are not deemed to be part of the instance which would entail that the unity of the instance is diminished. A lack of match between features – the essential learning condition – can only occur if the unity is preserved.

Learning from feature matching is a mechanism typically associated with category learning. Abstract concepts do not have many conditions of applicability as, for example, basic concepts have. For example, the concept of 'autonomy' has just one condition: autonomy applies if the patient is able to make an informed decision.

Besides the conflict during the assessment of applicability of concepts to a situation described above, conflicts can occur also once the concept is deemed applicable: despite a good match between features, a concept or schema may not provide the basis for a good solution or interpretation. This may lead to a revision of a solution procedure or interpretation, or to a reassessment of the applicability of the concept.

The integration of concepts

By integration of concepts is normally meant the relationing between concepts. Learners may recognise that concepts are similar or different, stand in opposition or are alternatives. This form of learning is discussed now with reference to the domain of ethics.

The value of ethics is most evident in situations where two or more ethical principles are in opposition. Ethical dilemmas have their origin in intrinsic properties of the principles and irreconcilable differences between them. Technological advances may exacerbate these differences. It is within ethical issues (such as euthanasia, abortion, etc.) that their meaning and applicability is questioned, and this occurs because the situation warrants the application of more than one. For example, while the definition of beneficence may be easily understood in terms of 'actions that do good' or 'actions that protect from harm', in several current ethical dilemmas it is unclear which actions are the 'good' ones, i.e. which ones would satisfy the principle. For example, while curing a patient from a disease is clearly a good act, prolonging a patient's life artificially may not be seen as such.

One hypothesis of the effectiveness of case-centred tutoring emphasises the role of learning from the integration of concepts. Specifically, cases often warrant the application of more than one concept, and their mutual contradictions may lead to a reflection on the meaning of the

involved concepts. To take again the example of beneficence, students may ask whether prolonging a patient's life artificially is 'doing good', and, as a consequence, learn that beneficence in medicine is not equivalent to the mundane concept of 'good action' (cf. Cassell, 2000).

The integration of concepts with concepts leads to another form of learning: it generates a conceptual system that can be employed to solve further problems. Knowledge organised as concepts integrated into a system is indeed one of the defining features of expertise.

3.3.6 Summary

The previous sections have presented learning from an educational and cognitive viewpoint. Some research on problem-based-learning has been cited as evidence that students learning almost exclusively with problems or cases (e.g. within a PBL curriculum) do indeed posses knowledge bases that are structured differently from students following a traditional curriculum. PBL students seem to integrate better basic conceptual knowledge with specific problem, and have good knowledge about when and how to apply conceptual knowledge. In simpler terms, their knowledge is more integrated. This research is especially valuable because, in contrast to most other research on learning from examples and problems conducted in controlled laboratory settings, it has high ecological value.

Models of learning from examples or problems have been introduced in these sections. A distinction is made between learning from one example, and learning from multiple examples. This latter form of learning is of particular importance because it is recognised as the form of learning that most likely lead to the acquisition of problem schemata. In order to be able to capture most phenomena occurring during a case-centred discussion, the sections have given a broad overview of models of learning. Special attention has been given to learning by applying an existing conceptual system that would permit students to explain cases (explanation-based learning). Students discussing ethics cases do indeed possess a mundane conceptual system of ethics, and, as will be described in chapter 6, readily apply it. The differences in explanation-based and instance-based problem solving can account for differences in learning.

These sections have introduced the foundations for the analysis of the small-group discussion, for their interpretation and also for the specification of the learning goals. They are hence the basis for a descriptive and prescriptive account of learning with cases. How these foundations are employed in these functions will be described in chapter 5 (coding scheme) and chapter 7 (learning design).

3.4 Processes and products of learning with cases

The previous sections of this chapter have presented an analytical framework for studying learning from cases, from which, in synthesis, a set of processes by which learners construct interpretations of cases are derived (

figure 4). These are common processes that people employ when studying material similar to cases (e.g. examples, problems, stories). Further, a set of common products are also derived (figure 5), which may be constructed by the processes, and which may constitute the learning outcomes of the discussions (cf. chapter 1).

Processes

- relating cases
    - relating cases and abstracting common/distinctive features
    - relating cases without abstracting features
- relating aspects and concepts (conceptualisation)
- relating concepts
- relating aspects
- abstracting a principle, a story (i.e. abstracting a structural feature of the case)
- analogies

Figure 4. A set of common processes learning employ when studying with examples or problems. The occurrence of these processes will be identified and will be the basis to characterise descriptively and qualitatively case-centred learning.

Products

- the interpretation (structure) of the case
- a new episode
- a knowledge base of episodes
- an instantiated concept or conceptual structure
- a domain-specific vocabulary
- a conceptual system

Figure 5. A set of common products that may be constructed when people discuss cases.

Chapter 4

Small-group case-centred discussions in current undergraduate education: context and learning design

4.1 Introduction

This chapter presents the educational context and learning design of a set of case-centred discussions on medical ethics that were held as part of the undergraduate curriculum at the UCL medical school. The discussions were video-taped and transcribed by the author of this thesis. They constitute the main source of data for the characterisations of small-group discussions as found in current practices. The discussions will be analysed and characterised in chapter 6 using the instruments developed for this purpose (presented in the next chapter).

As described briefly in chapter 1, the small-group discussions are embedded within a broad learning design that includes lectures and a plenary discussion held immediately before and

after them, respectively. This positioning influences the participants' overall goal: the lectures furnished the students with pertinent conceptual knowledge what affected how they interpret the cases (that indeed are concrete instances of generic problems of medical ethics); and further, they are required to summarise their 'findings' and to present them to a plenary.

A detailed description of the educational context and the learning design, including the learning goals set by the tutors, is necessary in order to analyse how the students interpret the cases, which topics they deem to be important and which 'conclusions' they draw. Of particular importance is a report of the lectures where the students were taught the pertinent concepts of medical ethics. These will be presented in the form of a domain model in the last section of this chapter. The cases themselves are also shortly discussed here, but are reported in detail in Appendix 2 and Appendix 3.

4.2 The educational context: the PDS module, the groups, the cases, the domain

4.2.1 Introduction

The following sections describe the PDS module, the part of the medical undergraduate curriculum that focuses on practical, ethical, legal and moral issues of the medical profession. It is within the PDS module that the small-group discussions are conducted. A section will also describe the substantive knowledge to be acquired by the students: specifically it will present a domain model of ethics principles that are pertinent to cases of euthanasia, the cases discussed by the students.

4.2.2 The PDS module within the medical curriculum

The PDS module teaches undergraduate medical students practical knowledge and skills required to practice as a medical professional. It introduces students to the situations that require physicians to make practical decisions and interact with patients. Knowledge about the law, professional standards, moral and practical reasoning, and communication skills are the focus of the module. The knowledge and skills taught is thus orthogonal to basic biomedical knowledge that is taught in most other modules of the medical curriculum. PDS modules are part of all years of the curriculum. The one described here takes place in the 1st year.

The PDS module includes coverage of ethics, law and moral questions. The inclusion of these questions in the medical curriculum is justified by a lecturer as: "the smallest action you decide

[...] in medicine, involves making decisions about values." The knowledge of professional standards, the role of ethics and the legal frameworks within which physicians operate are therefore essential knowledge for the medical profession. It should be pointed out that within the module ethics and law are not the only focus of teaching. Students come also in contact, for the first time in their career, with real patients in clinical placements that take place in hospitals and in primary care. In these placements students should acquire skills and knowledge related to effective patient communication. For the purpose of this thesis, these placements are not relevant.

On a broad scale, students become acquainted with the basic distinctions between ethics, law, and professional standards, and with practical reasoning. A lecturer introduces the function of part of the PDS module as: "[...] the Ethics & Law components of the course are these: one is learning the current law and professional standards; one is moral enquiry; one is practical reasoning. " For example, the students are taught that, when making clinical decisions, they can and should rely on guidelines of the GMC (General Medical Counsel), and that the GMC guidelines incorporate ethical, moral and legal issues. However, the purpose of the PDS module is not only to teach students those guidelines, which indeed could be followed quite blindly (i.e. without understanding the ethical, moral and legal background) but rather to help them reason about clinical situations. It is this general learning goal that is of interest in this thesis.

The PDS module is based on the conception that reasoning about clinical situations requires both substantive knowledge about ethics and law, and a scheme of practical reasoning. The following sections describe in detail what the learning goals are and what learning method is used to teach students.

4.2.2.1 The learning goals

As described above, at a broad scale students should understand the differences between ethics, law and professional standards. However, more important is, on the one hand, the acquisition of substantive ethical, moral and legal knowledge, and on the other, the ability to reason about clinical situations in order to make ethically, morally and legally sound decisions. A practical reasoning scheme is at the centre of teaching how to reason about situations.

The function of the practical reasoning scheme is introduced in a lecture in the following way: "Practical reasoning: all medicine involves practical reasoning which is reasoning leading to judgments about what should be done, and so when you go through a case and discuss whether the doctor did the right thing or not that's a matter of going through practical reasoning –

reasoning about whether the thing that was done was right. " The practical reasoning scheme distinguishes values from facts, each of which is distinguished into 'general' and 'specific'. For example, specific factual knowledge is the state of a patient's health, and general factual knowledge is biomedical knowledge that permits inferences on the prognosis of the patient. Values, in contrast, guide what doctors do with the factual information. For example, when dealing with a patient leading an unhealthy lifestyle, a physician should serve the patients' best interest by not only curing a current ailment, but by warning the patient about the consequences of continuing that lifestyle. Values decide what is good and bad, better or worse, right or wrong.

The reasoning scheme, applied to a specific situation, looks as follows (extract from the PDS textbook):

> Mr. Burns [a patient] drinks a great deal (fact, particular)
> Excessive drinking dangerous to health (fact, general)
> A doctor should make the care of her patients her first concern (value)
> ---
> Therefore Dr Bell should try to help him to reduce his alcohol consumption

The introduction of a role for values in medical decision making opens towards another core learning goal of the module: students should acquire substantive ethical, moral and legal knowledge to be able to reason about clinical situations without relying on generic guidelines. Making decisions requires sometimes to ask genuine value questions, and to answer them, substantive knowledge is required.

The substantive ethical knowledge taught in this first year centres on fundamental ethical principles: the principle of beneficence, nonmaleficence, and autonomy. These principles are first presented in a lecture; then, students are asked to reason about the principles in small-group discussion centring on cases of euthanasia.

In sum, the main learning goals of the 'ethics & law' part of the PDS module are the acquisition of a practical reasoning scheme, and the acquisition of substantive ethical and legal knowledge. The following section describes now how tutors organise the learning activities towards these goals.

4.2.2.2 The learning method and the learning support

The PDS module embraces, from the beginning, a more practice-oriented form of education: the clinical placements, using collaborative work and group learning, and the importance attributed to reasoning and decision-making attest to this.

However, some lectures are given. These lectures present generic definitions of concepts, present also frameworks to place the role of ethics, law, professional standards, etc. in context, and describe and exemplify core problems and difficulties of applying the conceptual knowledge. The lectures do refer frequently to real-world cases, and show the students how conceptual knowledge can be applied to them. For example, in discussing the value of 'having the patient's best interest in mind', the case of the heavy drinker is used to exemplify that the application of that value is not straightforward: what the patient's best interest is, is at times difficult to determine, and ethical conceptual knowledge may be required to make a sound decision.

Real-world clinical cases (scenarios) therefore have an important role in the module. In most sub-modules the presentation and discussion of cases compounds lecturing, and students are asked to think form their own view on the cases before being taught more factual (e.g. what are the GMC guidelines for this case) or conceptual knowledge (e.g. how this case should be conceptualised). Scenarios are used in all sub-modules focusing on ethical and legal questions, and often more than one case is presented.

Besides the lectures, small-group and plenary discussions are the core teaching methods of the PDS module. A sub-module is normally introduced by a lecture, and then one or more cases are discussed in small groups (3-4 students), whereupon these groups converge onto the plenary discussion. In the plenary, students present their conclusions, decisions and thoughts on the cases, and decide on a common conceptualization or decision of the cases.

Self-study has some role in the PDS module. Students are given, at the beginning of the semester, the PDS handbook, a compilation of organizational and substantive issues that includes also the cases used for the discussion. Students are asked to familiarize themselves with that material before coming to a lecture. Since the handbook provides all important information and knowledge, the use of specialized textbooks is encouraged only if a student has a particular interest in an issue.

The following section describes the small-group discussions in more detail.

4.2.3 The small-group discussions

4.2.3.1 Introduction

This chapter analyses 2 small-group discussions that occurred as part of the 1st year PDS module. The discussions are one of the three sets of data sets of this thesis. In the following sections, the context within which the small-groups discussions occurred, how they were organized, and what tutors expected students to learn, is described. The subsequent section presents the discussed cases, and followed by an introduction to the domain model.

4.2.3.2 The learning objectives and learning task

The overall learning objectives of the session within which the small-group discussion occur are specified in the PDS handbook as follows:

"By the end of this session, the students should be able to:

- explain what is meant by *practical reasoning*, *claims of fact* (general and particular) and *claims of value*.
- construct an argument leading to a practical conclusion, distinguishing between different kinds of premise involved.
- recognize the different kinds of problems that arise in the course of practical reasoning, distinguishing in particular between enquiries into questions of fact and questions of value.
- outline the GMC's list of duties of a doctor.
- explain the relationship between medical law, professional standards, and ethics as an enquiry."

The discussions were not the only means to achieve the learning goals. They were preceded by 2 lectures held in earlier weeks that introduced more generic knowledge on ethics and law, and by a morning lecture that focused explicitly on the concepts and principles pertinent for cases of euthanasia. The discussions occurred immediately after that morning lecture, and were then succeeded by a plenary session.

The lectures introduced the students to the role of values in medical decision-making, and to the ethics principles that are most relevant for physicians. The lecturer describes the medical profession as being "essentially practical", pointing out that the focus on practice entails the need for guidelines about how to do things. She presents a practical reasoning scheme that

should help doctors to "do the right thing", and introduces the distinction between facts and values. She then discusses that doing the right thing is never straightforwardly clear, since in many clinical cases it is uncertain what the patient's best interest is. She cites the example of Mrs. B (one of the euthanasia cases discussed by the students) as a case where indeed it is not clear whether the doctors should help her die peacefully and end her misery, or whether it is in the patients' best interest to continue to live. Decisions of this kind are presented in the lecture as decision based on principles. The lecturer cites the historical fact of denying anaesthesia to women in labour as an example of how early 1900 views on women have affected a medical decision. This fact demonstrates also how ethics principles or their use in decision making can change.

The role and importance of ethics in medical decision-making is then emphasised by pointing out that the rapid technological advances in medicine will put many practicing physicians into positions where they will have to rely on practical reasoning. For example, it is now possible to prolong a person's life to a degree where that person may not be considered anymore 'living' in a traditional sense. These passages refer directly to the cases of euthanasia that will be discussed by the students later the same morning. A summary of the practical reasoning scheme concluded the lectures.

The small-group discussion sessions are intended by the tutors to satisfy multiple learning objectives, though the focus is on the ability to reason on cases of medical ethics. The practical reasoning scheme is therefore most prominent in the learning objectives. Substantive ethical knowledge, such as the meaning of ethical concepts and principles, is given no explicit role at all, and is only pertinent in so far as it is necessary to formulate the arguments on the cases.

To achieve the learning goals, the tutors set a specific task for the students: to identify the facts (general and specific) and values that are pertinent for the cases. The formulation of an argument *for or against* the decisions made by the judges is not explicitly required. Instead, the students are asked to take a detached, analytical position on the cases, to frame the cases, as it were, within the scheme of practical reasoning. This appears to be in conformity to the main learning objective that is indeed learning to reason practically about cases of medical ethics rather than making decisions about them or understanding the applicable ethics. The framing of the cases within the reasoning scheme is also the required concrete output of the discussions, to be presented in the plenary session. In sum, the learning objectives and task set do overlap: students should apply the reasoning scheme taught in a lecture to the case, and thus become proficient in practical reasoning.

4.2.3.3 The groups

5 small groups were formed at the beginning of the discussion session. The number of students composing the groups varied from 3 to 5. Students are assigned randomly to the groups, in dependence of their initial location in the room. Since it is likely that that initial location is partially influenced by personal relationships between students, it is possible that some groups are composed of students that have been in the same group before. Data about the familiarity of the group members with each other have not been collected.

The discussions of 2 out of 6 small groups were videotaped. These groups were composed of 3 (group 1, 3 female) and 5 (group 2, 3 female, 2 male) members, respectively. The author of this thesis transcribed the discussions by looking at the video stream, and serialising the verbal contributions. The utterances were transcribed into a Microsoft Excel files. The students' utterances were transcribed as they were spoken, even if the word is not officially of the English language (e.g. "gonna" = going to, "'cause" = because, etc.). In figure 6 the transcript notations are presented.

[] – **time stamp**. Time stamps are inserted randomly. E.g. [4:59]

text...text – **short pauses within** an utterance. E.g. **"how did she..., she's"**

... text... – **utterance slightly overlapping** with the previous and/or the subsequent utterance

() – **non-verbal actions**, including (interrupts) (nodding, looking at sheet, etc). E.g. (shakes head)

* – **unclear** word or sequence of words. The number of stars corresponds to the number of unclear words or length of sentence (* = 1-2 words, ** = 3-5 words)

{} – **unclear** word or sequence of words, but **possible words** are presented, separated by slashes. E.g. {of/in?}

Figure 6. The notations used to transcribe verbal and non-verbal behaviour from the videotapes.

4.2.3.4 The tutors

Two tutors were present during the discussions. The tutors did not act continuously as facilitators for a single group, but attended to all groups. Their role was to guarantee that the discussions proceeded in line with the organizational outline of the module. The tutors did participate at times and randomly in the discussions, listening to student interventions, and, if necessary, reminding the students of the task. With some exceptions, the facilitators did not affect the content of the discussions.

4.2.3.5 The environment

The small groups were located in the same room, either around a table or sitting in a circle in chairs. The use of learning aids and the learning material differed from group to group. Each member of group 1 composed of three students and sitting in a half-circle around a table used her own notepad to make notes. Group 2, composed of 5 students and sitting in a half-circle, had assigned the role of 'note-taker' to one of the students. All groups had at least one copy of the PDS handbook, and one copy of the cases available. A student of group 2 had brought with her a copy of the GMC manual.

4.2.3.6 The cases

Two euthanasia cases were discussed in the small groups, the case of Mrs. B and the case of Mrs. Pretty. The cases are reported in appendix 2 and appendix 3, respectively, in the form they were presented in the PDS handbook and used during the discussion. A few years before the discussions took place, both cases had been at the centre of media reports, and discussions and editorials in mainstream UK media. Euthanasia is clearly a critical ethical issue promoting reflections on the opportunities of modern medicine and its possible implication, and question about quality of life and about the autonomy of individuals.

The cases were shortly mentioned in the lectures as exemplifications of these critical issues. The students had known about the cases from media reports, and were aware of the ethical questions the cases raised and still do.

4.2.4 The domain

4.2.4.1 Introduction

The following section presents a small domain model of ethics. The functions of the domain model are, first, to help the interpretation of the students' contributions, and, second, to assess whether the students have interpreted correctly the cases, i.e. whether the interpretations reflect the normal dilemma of euthanasia cases. These two functions will be discussed further in the next section.

The domain model has not been taught as it is presented here in the lectures. The lectures preceding the small-group discussions presented ethical dilemmas and euthanasia cases, but did not introduce the students to the basic ethics principles as outlined in the following sections. However, the domain model is necessary in order to interpret the discussion because the discussion focuses, mostly implicitly, about the ethics principles and their relations (including the dilemma). Indeed, as will be described in section 6.2, the students did not follow the task set to them ("to engage in practical reasoning by identifying facts and values"), but rather attempted to justify their own opinion about the cases. Specifically, the students disagree with the judges' verdicts (the verdicts dismissed the patients' requests), and attempt to make and argument that would support the patients' request. That argument revolves around the ethics principles represented in the domain model.

The model was compiled from a few sources on medical ethics and especially by a research on current contents of lectures on medical ethics. The model presented here is accepted in the health community as a "simple, accessible, and culturally neutral approach to thinking about ethical issues in health care" (Gillon, 1994). Cases of euthanasia are normally discussed within this approach.

As is frequent in moral and ethical problems, also on euthanasia it is impossible to have a clear, unequivocal and defensible position (unless it is determined, for example, from a dogmatic position). In euthanasia, the problem may be exacerbated by the continuous development in medical technologies and in societal consensus (these may derive from considerations or developments other than moral or ethical).

Cases of euthanasia are commonly interpreted within contrasting ethical principles and moral values. The different 'actors' in a case of euthanasia may refer to standard ethical principles in order to support their decision or viewpoint. In a sense, the contrast between principles is concretely reflected in the relationships between the actors: it is the patient's wish, supported her family's empathy, that contrasts with the duties of physicians; the judicial system does, to a certain extend, function as an arbiter, but it is constrained also by ethical principles that only

they (the judges) are bound to observe (first among them is the principle of universalisibility, see footnote 4, page 101).

4.2.4.2 Functions of the domain model

The domain model serves two functions: first, to help the interpretations of the students' contributions, and second, to assess whether the students have generated the correct representation of the cases. In this second function, the model is a normative model, i.e. it serves as a reference point for answering the question whether the students have acquired a better understanding of the domain of ethics.

However, learning gains in the domain of ethics cannot be evidenced in this study because the students possess already some lay knowledge about the domain and about euthanasia cases specifically. More in particular, the students have a sense about why euthanasia cases are ethical dilemmas. For example, they know that physicians cannot help someone to die because they are aware that a physician has a duty to prevent death and to prolong life. However, they also know that patients may suffer extremely and are beyond medical help, and that a 'good and gentle death' would be the preferable option for them. In a sense, then, the students have some lay knowledge about euthanasia cases, and about the general principles and their (contrasting) relations.

4.2.4.3 The ethics principles and their advocates

The principles primarily applicable to cases of euthanasia are: beneficence, nonmaleficence, autonomy and universalisibility[4] (cf. Beauchamp & Childress, 1989). These principles serve as the basis to justify or demand specific action or behaviour. Following are such specifications (bracketed items are for illustration only):

1. autonomy
   1.1. individuals' rights to chose and right to act on that choice
   1.2. (respect for individuality)
2. beneficence
   2.1. promote good

[4] Universalisibility is sometimes subsumed under the concept of "justice" (e.g. Gillon, 1994). The demand that all people should be treated equally is similar to the requirement that similar decisions should be taken in similar cases. From this reasoning derives the principle of universalisibility: it states that rules or a reasoning underlying a decision should be applicable to all (imagine, future or current) similar situations.

2.1.1. early death may be preferable to prolongation of life, depending on 'quality of life'

2.2. prolong life, prevent death, prevent harm[5]

3. nonmaleficence
   3.1. cause no harm
   3.2. (guide to chose treatment plan)
4. universalisibility
   4.1. rules are equally binding for everyone in the same situation

As mentioned, these principles are referred to by the main players/actors to justify and/or demand action in a case of euthanasia. These actors are: patient, doctors, judges (including high court), relatives of patient, and the GMC (General Medical Council).

One of the students' unassigned tasks is to determine whether a principle is applicable in the specific case under discussion. For example, the principle to respect a patient's wish, contained within the principle of autonomy, requires that the patient is able to demand a specific intervention (or the withholding of a treatment). In situations with patients living in a persistent vegetative state and thus unable to communicate, the principle does not apply. A necessary condition for the principle of autonomy to apply as a whole is therefore that the patient is able to give an *informed consent.*

The conditions of applicability for ethical principles are few. For example, both principles of nonmaleficence and beneficence require that there exists a 'duty of care' relationship between patient and doctor. However, some concrete conditions of applicability must be satisfied. They are the following:

- autonomy
  - patient must be able to make an informed decision
    - feature: clear mind, able to understand choices, able to make decisions
- nonmaleficence
  - there must be a physician-patient relationship
- beneficence
  - the quality of life must be deemed too low by the patient

[5] These two meanings of beneficence are in opposition, and present a dilemma in euthanasia cases. A 'good and gentle death' may be seen as the preferable option for patient with no quality of life, and hence assisting to such a death may be seen as 'doing good'. Active euthanasia may hence be sanctioned by this interpretation of the principle of beneficence. Clearly, this contrasts with the meaning of beneficence as 'preventing harm'. A doctor assisting a patient to die cannot be said to 'prevent harm', and hence the two meanings of beneficence are contrasting. In the following sections, it will be clearly specified which of the two meanings is intended.

        - feature: current extreme suffering
    - the opposite of a 'good and gentle death' must occur with near certainty in the case of no intervention
        - feature: future painful death with near certainty
- universalisibility

4.2.4.4 Ethical dilemmas of euthanasia cases

The main dilemma in euthanasia is the following: invoking the ethical principle of autonomy, a patient would challenge a physician's principle of nonmaleficiance, but also some of the medical profession's standards such as the need to maintain at all costs a curing and caring relationship with the patient. Further, while physicians are constrained, in addition to professional standards and principles, and their own morality, they are also bound to observe the law. Hence, the third and most important player in euthanasia cases is the legal profession. While they cannot solve moral and ethical dilemmas in principle, they at least can provide arguments and justifications for binding decisions. Judges and lawmakers are themselves bound by a principle relevant also for clinical decisions, the principle of universalisibility.

A patient may further invoke the principle of beneficence, which requires physicians to 'promote the good'; a 'good and gentle death' may indeed be seen as 'good' or by some standards 'better' than an existence with a very low quality of life (e.g. if the patient is suffering intensely).

Other, more societal and general views have a bearing on euthanasia cases. For example, several scholars have argued that the legalization of physician-assisted suicide might thwart society's resolve to expand services and resources aimed at caring for the seriously ill, eventually dying patient. This argument embodies the approach to euthanasia as a public rather than private matter. Figure 7 represents the dilemmas.

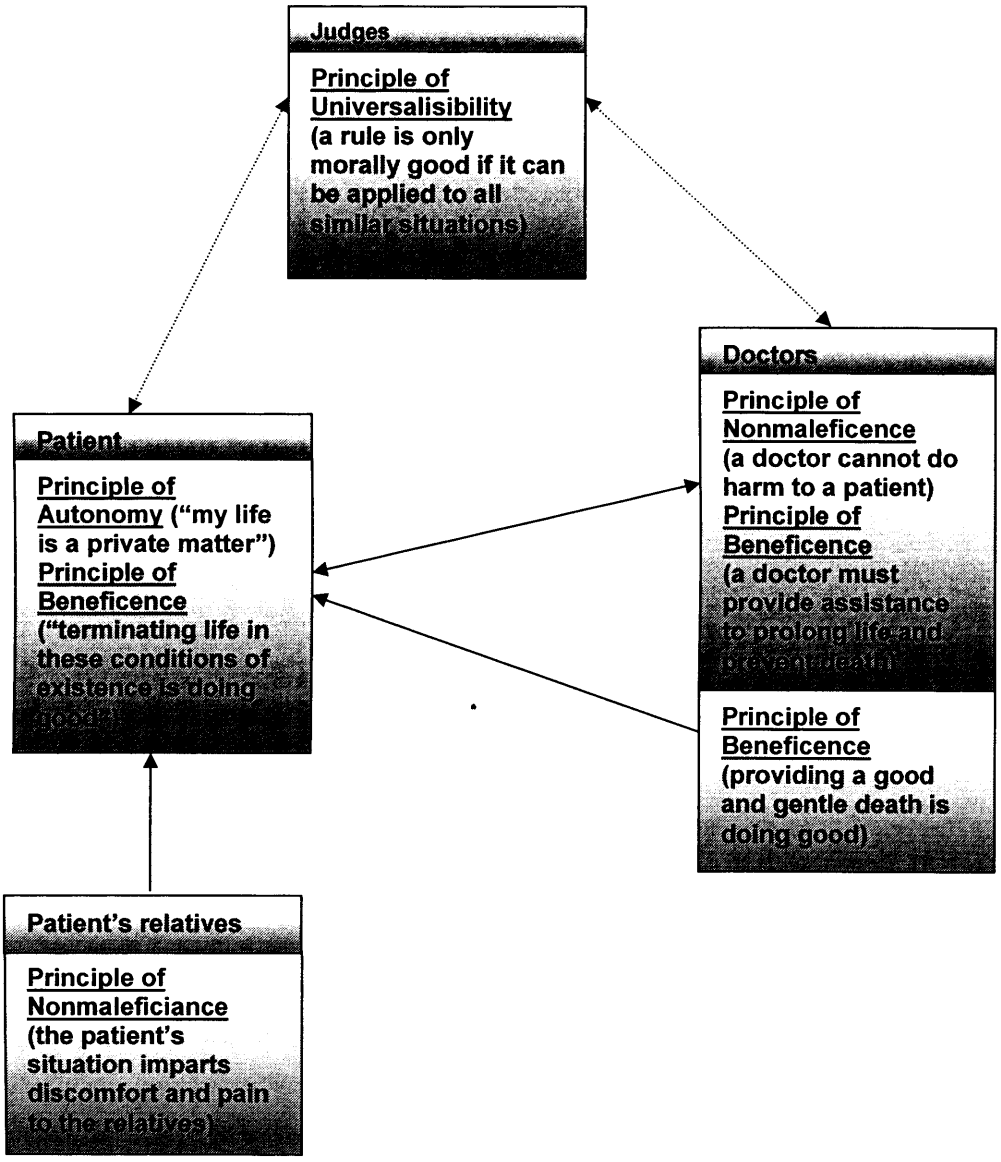

Figure 7. The diagram represents the principles and the major actors/players in cases of euthanasia. Single-sided arrows between players represent support of a player, while double-sided ones represent opposition. The diagram represents the situation where a patient would argue, on the basis of the principles of autonomy and beneficence ('good and gentle death'), that she has a right to terminate her life and that doing so would mean 'doing good'. Physicians are, in contrast, constraint by the principles of nonmaleficiance and beneficence (prevent death, prolong life). The patient's relatives would rely on the principle of nonmaleficiance to support the patient's demand, because the situation represents a major discomfort in their lives. The judges' role is represented here only as verifying that, if a decision is made on the case based on an argument involving the application of principles, that decision is universalisable. This is especially the important with regard to the principle of autonomy, because not all demands of patients can be readily accepted.

4.3 Summary

This chapter described in detail the educational situation within which the small-group discussions that will be analysed and characterised in chapter 6 were embedded. These aspects constitute the overall design of the specific learning situation and they will be critically analysed in relation to their role in engendering conceptual change in chapter 7. The chapter also presented the cases and the domain of study. From a most general point of view, the processes and 'products' identified in chapter 6 result from the students' continuous effort to interpret the cases in relation to the taught domain model, giving rise to the particular forms of knowledge construction that characterise this form of learning. The processes will be identified through analysis instruments developed for this thesis. These instruments are presented in the next chapter.

Chapter 5

Analysis instruments

5.1 Introduction

This discussions presented in the previous chapter are analyzed with three analysis schemes developed for this thesis: (1) a scheme identifying cognitive processes from what the students say, (2) a scheme to identify topical relations between episodes, and (3) a scheme to identify whether students develop novel conceptualisation in the course of the discussions. These schemes are presented in detail in this chapter bridging the theoretical basis of the data interpretation (chapter 3) with the data analysis and the interpretation itself. Coding schemes can indeed be seen as mappings between a theory or model, and the final output of research on qualitative data (Chi, 1997).

The chapter introduces the analysis schemes by discussing shortly similar work, the generic structure of dialogue coding schemes, and common methodological issues of such schemes (especially the grain size, and the criteria of completeness and coherence).

The three main sections of this chapter (process analysis, section 5.3; analysis of conceptual change, section 5.4; episode-focus analysis, section 5.5) present the coding schemes in detail. For each of them, the target phenomenon, the target units and the coding procedure is described.

5.1.1 Similar work

The analysis schemes presented here shares a few essential features with content analyses used in similar research. The two most important shared features are, first, the underlying assumptions about what the content of utterances can tell us, and, second, its employment as a tool to gather evidence of learning where learning is defined with reference to a model. The following sections introduce similar work focusing on what aims that research has pursued, what its assumptions on the content of utterances is, and how coding schemes employed in that research relate to and are developed on the basis of models of learning.

5.1.1.1 Aims

Recently, much research has focussed on dialogues to derive various measures of learning. For example, Newman et al.'s (1997) work grew out of the necessity to "evaluate the quality of learning when students were doing seminars" and assess whether "key learning objectives" were met. The authors define 'quality of learning' in terms of measures of deep learning, and contrast this to surface learning. In surface learning, student would skim, memorize and regurgitate the learning material for tests, while in deep learning they would try to develop a critical understanding of the material. The authors developed a content coding scheme to evidence deep learning in students' dialogues, relying on a specification of cognitive processes (such as critical thinking) involved in deep learning. Their coding scheme consists of a set of indicators that capture these processes (such as problem identification, problem definition and problem integration) in dialogues. By applying the coding scheme to student dialogues where the students were located in different learning environments (a computer-based discussion forum versus a 'natural' face-to-face environment), the authors showed that computer-supported discussions lead to significantly deeper processing of knowledge than face-to-face discussions (Newman, Webb & Cochrane, 1995).

Also the research of Hara, Bonk & Angeli (2000) aims to derive an assessment of the quality of learning from the analysis of the content of utterances. In a way similar to other work, quality of learning is redefined in terms of processes and of the criterion of 'depth of processing'. The authors make several assumptions about how 'depth of processing' can be evidenced in dialogues, assumptions that relate to the elaboration of the learning material and of knowledge introduced into the discussion. The depth of processing is, for example, related to 'making

inferences', 'making judgments', and 'proposing clarifications'. More in general, processes that demonstrate the students' deeper involvement with the learning material are deemed to show depth of processing.

This and other work is based on the assumption that learning manifests itself in the processing of information and knowledge, and that content analysis can be employed to evidence that processing.

5.1.1.2 Model-based coding schemes

It is common that content analyses are based on a model of information processing and learning. As described, when research aims to derive measures of the quality of learning from dialogue data, a model of learning is often the basis of the definition of quality of learning. By model of learning is meant here a description of how knowledge is developed by specific processes that operate on information and knowledge. Models incorporate also learning objectives, and specify what knowledge should be acquired; however, models focus generally on how that knowledge is acquired, i.e. which processes operate on representations and generate representations.

Models that serve as bases for content analysis may be sophisticated but relatively small-scale targeting a specific form of learning or larger-scale incorporating diverse processes drawn from a variety of theories of learning and education. As an example for a small-scale model used as the basis for a content coding scheme may serve Garrison's (1992) model of critical thinking. It has been used to identify instances of messages or units of smaller grain size that are evidence for deep thinking (Newman et al., 1997). Garrison (1992) distinguishes 5 stages of progressively 'deeper' critical thinking. These stages manifest themselves in students' contributions in different kinds of processing of information. On the basis of the model, a large set of indicators were developed that would capture whether an utterance is indicative for deeper or shallower processing of the learning material or the knowledge introduced by other students.

Garrison, Anderson & Archer (2000) rely on an 'inquiry' model to classify utterances into categories of cognitive processes. Their aim is to capture "deep and meaningful learning" in a variety of learning environments. Their model distinguishes different stages of inquiry, such as 'exploration', 'integration' and 'resolution'. Each of these process categories is associated with indicators (such as 'connecting ideas' and 'applying new ideas') that are evident in utterances.

5.2 The structure of coding schemes

Schemes of analysing data of people's verbal or written expressions need to specify a mapping between a model or theory and the data (Chi, 1997). Examples for that mapping have been presented above. For example, Garrison, Anderson & Archer (2000) present their coding scheme as a mapping between a model of critical thinking, and indicators that are evidence for critical thinking in utterances. Mappings between a model and a set of indicators go back as far as protocol analysis. Protocol analysis (Ericsson & Simon, 1993) is used to provide evidence for a normative model of problem solving whose atomic constituents are the initial state, the goal states, a set of operators and a set of selection rules. In this form of analysis, the scheme used to analyse think-aloud protocols was specified on the basis of a mapping between Newell & Simon's (1972) model of problem solving and the verbal expression of the components of that model.

Within the dichotomy of the contrasting analysis techniques of verbal and protocol analysis, the analyses presented here share features with both, though more so with verbal analysis. For example, verbal analysis, in contrast to protocol analysis, does not aim to validate a normative computational model of problem solving, but is interested in differences in mental representations. Further, since protocol analysis attempts to verify problem solving processes, the sequence of expressions is crucial: whether the actual problem solving process of a human subject conforms to the computational model depends not only on what rules, operators, etc. are chosen, but also when, i.e. in what sequence. For verbal analysis, the sequence is of less relevance because any expression deemed to represent a mental representation of, for example, an external problem is valuable information to derive conclusions about that representation. An exception is the uncovering of problem solving steps that are dependent on what conceptual knowledge is retrieved from memory. The sequence of expressions is of no relevance of the process analysis presented here, because the model of learning does not specify in what sequence learning processes are employed, but only which (evidencing of analogies is an exception because analogies occur within a well-defined sequence of similarity assessment, mapping and transfer). The sequence of utterances has some importance for evidencing conceptual change, because, obviously, the aim of that analysis is to verify whether the conceptualisation of the cases change *over the course of the discussion.* The sequence of expressions has also only minor importance to the episode-focus analysis: it is only relevant in so far that the analysis targets the focus of adjacent episodes (see section 5.5).

It is possible that the process analysis may be seen in contrast to protocol analysis with regard to one crucial characteristic: the assumption that the verbalisation affects the outcome. Protocol analysis must assume that thinking-aloud does not affect the performance while solving a problem, and clearly, that while thinking aloud no learning occurs. Rather, the protocol resulting

from thinking-aloud is assumed to be a faithful mirror of the problem solvers' path through the problem space.

To return to the notion of mapping, two more examples are cited: schemes of verbal analysis normally specify a mapping between a model of knowledge representation and the terminology used to describe problem situations (e.g. Chi & Bassok, 1989). Schemes looking for processes in utterances (Bullen, 1998; Fahy et al. 2000; Newman, Webb & Cochrane, 1995) rely on a mapping between a model of knowledge processing and a set of indicators.

In general, hence, these analysis schemes make a basic distinction between the phenomena of interest (the target phenomena) and their indicators (coding categories; Chi, 1997 also uses the label 'target units'). The indicators are those 'signs' in expressions that represent the target phenomena in a body of data. In the following sections, several examples of target phenomena and indicators will be presented.

The basic structure of a coding scheme is composed of specifications that answer the following questions:

1. which are the target phenomena of interest that the output of the application of the coding scheme must give answers to?
2. which are the assumptions that relate the target units to the target phenomenon?
3. which are the target units of analysis that may provide evidence for the target phenomena?

These questions are the basis for the structure of a content coding scheme. Each scheme will need to answer the question in order to specify the coding categories (and coding procedure), to capture the phenomena of interest in the data, and to answer the research questions. The presentations of the coding schemes in this chapter have been structured around answers to these questions.

Before presenting the details of the coding schemes, however, two important generic features of coding schemes will be discussed: the unit of analysis, and the identification of positive and negative instances.

5.2.1 The units of analysis (grain size)

To prepare a data body for analysis, it needs to be segmented into the smallest meaningful units to be categorised according to the coding categories. The process of specifying the smallest unit of analysis is sometimes called unitising (Rourke et al., 2001). The goal of unitising is to select a unit that exhaustively and exclusively encompasses the sought-after construct (the target

phenomena). Unitising depends on the research questions being asked. For example, if the research aims to investigate the occurrence of explanations of a text in students' contributions, the unit is most likely to be the propositional unit, because it is likely that explanations are expressed in a single proposition. Research investigating features of text-based communication (chat or discussion forum) such as the average length of a message, the unit of analysis is the entire message.

There is an obvious tendency to use syntactic criteria for unitising, because such criteria can be independently verified and used by different coders. Syntactic criteria are preferred because they rely on clearly evident features of a contribution, and hence permit a 'mechanical' unitising of the data body. Syntactic units are, for example, the sentence or proposition, the entire message, or even entire paragraphs. Syntactic unitising can be done more easily in research focusing on clearly evident aspects of communication.

In content analyses, syntactic unitising is often not applicable especially when the analysis attempts to capture phenomena that may be expressed in a variety of ways. The identification of an 'idea' is an example where syntactic unitising is not helpful. Ideas can be expressed in a single small proposition, in more than one proposition or even across utterances.

Research papers discussing the issue of unitising caution prospective analysers against too much zeal in attempting to specify the units in terms of objective features, though obviously this remains the ideal form of specification. For example, Krippendorf (1980) describes the process of unitising as involving considerable compromise between meaningfulness and reliability. The author refers here to the well-known dilemma of researchers working with content coding schemes: what is meaningful for one researcher may be less or not at all so for another. Such differences in interpretation decrease the reliability of the coding scheme. Also Chi (1997) recommends that, though the units should be fixed in advance (i.e. before the actual coding) as much as possible, some flexibility is needed to generate more valuable data.

In this thesis, the unit of analysis of all three coding schemes is the proposition i.e. the syntactically defined expression consisting, at the minimum, of subject, object and verb; however, some flexibility is accepted when a coder wants to increase the unit size. This way to unitise is especially important for the process-coding scheme. But it is also particularly difficult, because the target phenomena of the scheme are learning processes, and it is possible that such processes manifest themselves in more than one proposition.

As described, the target phenomena of the process analysis are learning processes. These may manifest themselves over a few utterances, or the same process may occur in sequentially adjacent utterances. For example, an aspect may be brought into the discussion in utterance X,

and then conceptualised in utterance X + 1. In these cases, the two utterances are deemed to represent one process (conceptualisation of an aspect), independently of whether the utterances are of the same or of different students. Joint knowledge construction, intended as being distributed over different students (e.g. McGregor & Chi, 2002; Barron, 2000), is hence not considered in this analysis.

Unitising is of no importance in the scheme capturing conceptual change. This is because the analysis does not attempt to give an exhaustive classification of all meaningful units (a process that is necessary for a quantification), but rather picks out those units that are evidence for conceptual change.

The unit size of the third analysis (that targets the relations between the foci of students' messages) is the message (i.e. the contribution as a whole of a specific student). However, a message may have more than one focus, expressed in different propositions that compose it. To identify the focus of a message, it hence needs to be divided, as a first step, into propositions. Then the focus of each proposition is identified. The focus of the entire message is then taken the focus of the proposition that ends the message.

The discussion on the grain size of the coding scheme has not been extensive here, because the application of the coding schemes did not present substantial difficulties that would have required a more thorough discussion. That is, the identification of learning processes could normally rely on the propositional unit alone without requiring extending the unit. Also the third analysis (relations between foci) could rely always on the message unit, because, even if the message was composed of different propositions, these propositions had a common focus. In a sense, then, the specification of unitising presented here for each of the coding schemes is sufficient.

5.2.2 Criteria of content coding schemes: objectivity and reliability

Whether content coding schemes are objective methods to analyse dialogue or verbal data and to derive solid research findings from their application is continuously debated in the research community. Content analyses are a form of interpretative research method, and it is common that these methods are scrutinised on whether they satisfy essential criteria of scientific research. Three characteristics are regarded as especially important: objectivity, reliability and replicability. Objectivity may be seen as the central measure of a content coding scheme because it refers to the extent to which categorisation of sections of transcripts is subject to influence by the coders (Rourke et al., 2001).

Most content coding schemes indeed require coders to make a decision whether an identified unit can be categorized according to one or more of the relevant coding categories that compose the coding scheme. This categorisation is especially difficult when relatively undefined mental 'objects', such as 'ideas' or 'inferences' are to be identified from the content of utterances. Since that identification depends to some degree on the view of the coder, the objectivity of content coding scheme is often questioned.

The single most important criterion to increase the objectivity of content coding scheme is inter-rater reliability. Inter-rater reliability refers to the degree of concordance of two or more raters with regard to the classification of a unit of analysis. Quantitative measures of inter-rater reliability have been proposed by the statistical sciences, and the most commonly used one is Cohen's kappa (Cohen, 1960). The measure reflects the number of agreements per total number of coding decisions, and incorporates also a quantity reflecting the possibility of chance agreement between raters.

The measure of inter-rater reliability would be calculated only on a limited sample of the data body. Specifically, while a first rater would code the entire data body, a second rater would code it only in so far as necessary to derive the reliability measure. The randomly chosen sample would consist of about 10% to 20% of the entire data body (Rourke & Anderson, 2004). The next question regarding reliability is what measure of inter-rater reliability would be acceptable. According to Rourke et al. (2001), the inter-rater reliability of coding schemes applied on real-world data and published in the pertinent literature ranges from low (0.6) to high (0.9). Normally coders should strive to achieve a measure of 80% (0.8), but the authors claim that it is "premature to declare a conventional level of acceptability". The authors take a cautionary approach towards an increase of reliability arguing that manipulations of the unit size or other interventions on the coding scheme carried out in order to increase reliability may simultaneously decrease the validity of the research. They echo Krippendorf's (1980) caution about the fact that "reliability often gets in the way of validity". In practice this means that the 'expulsion' of units classified according to one of the categories of the coding scheme or the inclusion of other previously left out reduces the epistemological value of the data. In other words, to produce a valid, novel and interesting output by applying a content coding scheme, reliability should be respected by not stressed too much.

Some authors argue that the relative novelty and still pioneering character of research with content coding scheme calls for a more lenient and pragmatic approach regarding reliability. For example, Newman, Webb & Cochrane (1995) describe their coding approach as being influenced by pragmatic and temporary solutions: "rather than classify every statement in a transcript, we mark [...] only the obvious examples, and ignore intermediate shades of grey.

This eases the task of the assessors, since there is less need for subtle, subjective borderline judgments..." Also Chi (1997) describes the procedure of coding as an imperfect science. She warns that schemes for qualitative analyses do generally map imperfectly into the particular model or theory they are poised to verify. Rather, devising a scheme is often a process that, besides a model-driven top-down specification of the units of analysis, "includes also influences of exploratory bottom-up".

5.3 The process-coding scheme

5.3.1 Introduction

The following sections introduce the process-coding scheme, the scheme that aims to capture which learning processes occur when students learn with cases. The scheme is based on the framework presented in chapter 3. In that chapter, learning with cases has been conceptualised as the high-level process of "structuring a case". The chapters focused on what learning processes occur when a case is structured, and what learning products these processes may generate. The scheme presented here identifies only processes; learning products are inferred from the occurrence of specific learning processes. These inferences rely on a mapping that will be presented in section 5.3.5.

5.3.2 Assumptions

Content analysis schemes devised to interpret group discussions of learners rely on the assumption that the analysis of the content of utterances is a valid basis to derive conclusions about learning in collaboration. Henri's (1992) content analysis scheme is normally cited as providing the first and most important clarification of that assumption, as well as an application that sanctioned the assumption. Clearly, though the assumption should be justified on theoretical grounds, once application of content coding schemes give reliable result that may eventually be triangulated, the assumption will be strengthened. Here the theoretical basis of the assumption will not be discussed. Rather, it should be pointed out that the assumption has led to the development of coding schemes that have increase our understanding of aspects of collaborative learning, including the general quality of learning. In a sense, then, the relative success of the coding schemes sanctions that adoption of the assumption.

Newman, Webb & Cochrane (1995) describe this assumption as follows: "the cognitive dimension [of Henri's (1992) coding scheme] relates to the psychological processes taking

place during learning", and justify their focus on the cognitive dimension by stating that "other dimensions, such as the participatory or social dimension, lead to measures of quantity, not quality and tell us about motivations and conversations rather than the learning taking place". While most coding schemes developed differ in detail from Henri's, this assumption is still the main justification for them.

A similar assumption underlies the coding scheme presented in this section. This assumption does incorporate the earlier described one and adds to it: that the

> *learning processes that construct learning products manifest themselves in the contributions of the dialogue.*

It should be pointed out that this assumption isn't meant to imply that all processes are manifest or that only those that are manifest are productive in terms of the construction of learning products (see section 2.3 on collaborative learning). Rather, the interest of this thesis is in describing how learning occurs and as it is evidentiable in a dialogue (see chapter 1).

5.3.3 Target phenomena of the process analysis

As described above, the first component of a coding scheme is a set of target phenomena that relate directly to the questions the research is attempting to answer. In this thesis, as in other work whose research technique includes a content coding scheme, the target phenomena are specified on the basis of a model. In this section, it is described how the target phenomena derive from the model (presented in chapter 3).

Chapter 3 has presented a conceptualisation of learning with cases as the high-level process of "structuring a case" (akin to conceptualising and interpreting a case). Learning with cases has been described, on the basis of extant research, as involving a set of processes that transform information (the case) and knowledge into new knowledge. These processes are the target phenomena of the process-coding scheme. The review of the literature identified 6 basic processes, and one complex process (analogies) (see section 3.4 for a summary).

The basic processes are the following:

- relating cases (section 3.3.4.3)
    - relating cases and abstracting a common surface feature
    - relating cases without abstracting surface features
- relating aspects and concepts (concept instantiation) (section 3.3.5.4)
- relating concepts (section 3.3.5.4)
- structuring of the case (section 3.2.1)

- relating aspects
- abstracting a principle, a story (i.e. abstracting a structural feature of the case)

- analogies (section 3.3.4)

These target phenomena are the basis upon which the coding categories are defined. Clearly, a coding scheme should maintain a one-to-one mapping between the target phenomena and the coding categories (target units). That is, for each target phenomenon only one coding category should be specified. Further, the definition of coding categories can be a set of rules for the categorisation of the units (see section 5.3.6). The definition of the coding categories answers the following question: "what is acceptable evidence that a specific unit is an instance of one of the target phenomena". The answer to this question is the subject of the next section.

5.3.4 Categories of process coding

This section describes now the coding categories. Coding categories may be seen as the operational equivalents of the target phenomena, i.e. they represent the target phenomena, but are specified so that the target phenomena can be identified in the data body. The specification of the coding categories is the most difficult and error-prone stage of developing a coding scheme because their function is to capture real-world data, but they rely on abstract specifications derived from the model or theory. Thus, the coding categories are to accommodate both abstract specifications and "messy" real-world data (Chi, 1997).

The specification of coding categories is driven by the requirement that they should be usable by coders who are unfamiliar with the questions being asked by the research and the underlying model or theory. That is, coding categories should be specified to permit their almost 'mechanicistic' application to the data (for a similar requirement of the coding procedure, see section 5.3.6.3). This requirement derives from the need to increase the objectivity of the coding and to eliminate interpreter bias (Rourke et al., 2001). It is well known that researchers tend to see too many positive instances in a data body, i.e. instances that confirm the hypothesis the researcher wants to verify. Coding carried out by a coder who is unaware of the research, also called 'blind' coding, decreases interpreter bias, and increases the overall objectivity of the coding and reliability of findings.

As said, the specification of coding categories is largely the description of what constitutes, in the data body, evidence for a target phenomenon. For example, to assign the category 'relating cases' to a proposition, specific indicators must be present in the proposition. The presence of one or more indicators in a proposition is the basis upon which a categorisation of the

proposition is made. The specification of the coding categories is a list and a description of these indicators.

The process-coding scheme uses two kinds of indicators: *reference* and *keywords/key phrases*. These general kinds of indicators and their theoretical basis are described now.

To describe the indicators, a short review of the basic components of the framework is helpful. The framework describes learning as a set of processes that generate a set of learning products. Learning processes operate on knowledge and information[6] and hence the identification of information and knowledge is a first step towards the identification of the processes. For example, if a student draws attention to the similarity between two cases ("this situation is similar to [another one]", the proposition mentions the two "situations", and establishes a relationship of similarity between them ("...is similar to..."). A proposition of this kind is a positive instance of the coding category 4.

However, to capture not only explicit mentioning of specific facts, concepts or cases, *references* to implicit facts, concepts or cases are used to identify a unit where a learning process may be evident. A reference is a surface expression that points to a concrete aspect (fact), a case or a concept that employs a term that is different from the one used in the cases and lecture material. For example, the fact that Mrs. B is "of sound mind" can be mentioned in exactly this surface expression, or in an expression that refers to this fact. Such a reference would be, for example, "Mrs. B was of healthy mind" or "Mrs. B understood what was going on with her". The indicator of reference – rather than mentioning – is used because students may use a variety of surface expressions to point to the same aspect, concept or case.

An example of mentioning a concept or principle is: "that would violate her autonomy". A reference to the same concept would be: "then she is not free to make her own decisions". References to other cases are normally explicit such as in: "there was a similar case in ..." Clearly, explicit mentioning is the preferred form of indicator and it permits a well-justified classification of the proposition. References require some interpretation: whether a unit is categorised in a specific way is decided on whether a surface expression is related to the sought-after aspect or concept. In many cases, the relation relies on mundane knowledge. For example, the principle of autonomy is related to the idea of freedom, and hence a message containing the term 'free' (such as in 'free to choose') is coded as making a reference to the principle of autonomy.

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[6] To reiterate, by information is meant the case material, i.e. the un-interpreted description of the situation.

The second type of indicator is keywords (and key phrases) intended here more as 'telltale' signs upon which a decision of the occurrence of a process can be based. Keywords are frequently used in content analysis schemes because they are reliable and objective indicators. For example, Chi & VanLehn (1991) use keywords such as 'because' and 'so' to search for 'explanations'. The presence of such keywords is an indication that the proposition should be classified as an explanation. It should be pointed out that the identification of explanations from such linguistic markers and limited to the propositional unit does not capture all instances of 'explanations' that may be offered during the discussion. Indeed, explanations may be expressed over several contributions and may be devoid of specific key words or tell tale signs (cf. Wilson & Keil, 2000). However, the research on explanations construction and other methods for identifying explanations in discourse is relatively recent and not yet well developed, and a well tested method is thus the preferred choice.

The keywords relevant in this coding scheme are used to identify the processes of relationing. Specifically, keywords indicating a comparison ("is similar", "is different") are used to identify propositions where cases are related to cases. Keywords indicating an explanation ("because", "so") are used to identify the relationing of aspects with concepts ('this concept applies because of this fact'; e.g. "she is free to chose because she is of sound mind"). A last set of keywords and key phrases is used as an indicator for relationing concepts as 'contrasting' or 'being in opposition'. These are keywords indicating contrasts, such as 'but' (for example, "they cared about her welfare, but restricted her freedom").

Having described the generic properties of coding categories and the two types of indicators used to classify units, the specific coding categories can now be presented (table 1). The specific indicators will be further discussed when presenting the coding procedure (section 5.3.6).

	process (coding category)	description	examples
1	**relating aspects and concepts**	applying a concept because of a specific aspects; emphasising that a concept applies because of an aspect; verifying whether a concept applies because of a specific aspect	"but she was of sound mind, hence she was able to decide for herself"
2	**relating concepts**	implying that concepts are related (e.g. are similar, depend on each other, are in opposition)	"a judge must chose between [this principle] or [that principle]"
3	**relating aspects**	relating two or more aspects. Relations are normally causal, but can also be 'dynamic' ones[7]	"the patient decided [in this way] because he was conscious"
4	**relating cases (from learning material or personal/public episodes)**	saying that two cases are similar or different; or implying that a similarity or difference between cases has been identified	"in this case here...while in that case there..." "this case is like the other"
5	**abstracting similarities/ differences**	emphasising an aspect that makes two cases similar or different	"these cases are similar/different because [here she was [aspect]]"
6	**abstracting principles**	providing a description of the case that captures its point, it story	"this is a case (problem) of [ethical principle]"
7	**analogies**	using another case to interpret a current case	"in that case, the [decision] [problem] was [...]; also here..."

Table 1. The table presents a summary of coding categories, their descriptions, and a few examples for each of them.

A few explanations and notes of the definition of the coding categories are in order, because there are some overlaps between categories, and some need a better description.

- process 1: the category 'relating aspects and concepts' includes only instances where the relationing between an aspect and a concept is made clearly and explicitly by the utterance. For example, an utterance such as "she knew what she wanted and she has a right to get what she wants" relates the aspect of 'patient's wish' to the principle of autonomy. The criterion of explicitly is needed because conceptualisation of aspects occurs very frequently if not ubiquitously. The high frequency of applicability of this category makes the coding meaningless, because it does not serve for a characterisation of learning.

[7] Dynamic relations between aspects capture the interaction between aspects, albeit only in an approximate way. They do provide, however, some structuring of cases. An example of a dynamic relation is "the more... the less" (cf. Forbus & Gentner, 1986). It should be pointed out that this kind of relationing does occur only rarely with the euthanasia case. But it is hypothesised here that it occurs with high frequency when people learn with more complex cases (such as business or management cases).

- processes 3 and 6: in situations that represent a contrast between principles (concepts) as is the case with the euthanasia cases, the abstract representation of the case corresponds to relating the contrasting principles. What is abstracted is hence really the contrast between the principles that apply equally appropriately to the case
- processes 4 and 5: a clarification is needed with regard to the difference between 'relating cases' and 'abstracting similarities/differences'. Both processes entail a similarity assessment between cases. However, the second category is applied only if that similarity is clearly identified and expressed. The first category applies also if the similarities or differences are not clearly expressed, but only entailed, such as in "this case is like the other". The distinction is made in order to capture the construction of an encoding vocabulary. As has been described in section 3.3.4.3, encoding vocabularies are generated from abstractions of similarities/differences (in addition to being taught domain-specific concepts). However, to be identified as part of a vocabulary, it is necessary that the similarity be labelled
- process 6: capturing the point or story of a case is an essential learning process whereby students acquire knowledge about problem types. That knowledge is useful to encode future problem situations. When typifying a case, the students will use their mundane knowledge, and especially mundane relational knowledge or mundane problem types. These abstractions constitute initial forms of problem schemata that are the basis for further development that occurs when more cases are studied.
- processes 4 and 7: an analogy clearly implies a relationing between cases; however, the two categories are distinct because in analogies, a solution or interpretation is carried over from one case to another. An example for merely relating cases is: "this is case is different from the other because this case has [feature X]". An example for an analogy is "case A is like case B, and in case B [solution X]/[interpretation X] was applied, and [X] applies also here".

5.3.5 Processes and inferred cognitive products

Before presenting the coding procedure, i.e. a about description how the coding categories are applied to the data, a short description of how the learning products are inferred from the occurrence of learning processes is presented now. The mapping between processes and products will be the basis of describing and evaluating collaborative learning with cases (chapter 6). The mapping is presented here in order to clarify the target phenomena and their relation to learning products.

The target phenomena of the process analysis are the processes of the elaboration of information and knowledge. It is necessary to mention specifically 'information and knowledge' because the processes that are identified occur over both information, i.e. the case description, and knowledge, i.e. contributions to the dialogue.

As described, the results from the process analysis will be used to characterise what is learned, i.e. to characterise learning in terms of learning products. The learning products are, in the process analysis, not target phenomena themselves, because there is no direct correspondence between these products and the target units.

The mapping between processes and products is based on the framework. Most mappings are one-to-one mappings. In other words, the occurrence of a specific process (such as 'relating cases') is deemed to generate or modify a specific learning product (such as the domain-specific conceptual system). Table 2 shows the processes that are the target phenomena of the process coding scheme, and the mapping between processes and products.

	learning processes	learning products
1	**relating aspects and concepts**	**concept instantiation**
2	**relating concepts**	**domain-specific conceptual system**
3	**relating aspects**	**new structured episode**
4	**relating cases: current or from other sources**	**knowledge base of cases**
5	**abstracting similarities/differences**	**encoding knowledge**
6	**abstracting principles**	**encoding knowledge; problem types**
7	**analogies**[8]	**knowledge base of cases; encoding knowledge; domain-specific conceptual knowledge; new structured episode**

Table 2. The table presents the mapping between processes and products. The mapping is used only in the interpretation of the output of the process coding, not the coding itself.

[8] As is evident, analogies generate several types of cognitive products; in way, they have a great effect upon the cognitive structures involved in them and also may generate novel abstract knowledge (see section 3.3.4 for an in-depth discussion on analogical learning).

5.3.6 Coding procedure

5.3.6.1 Notes on coding procedures

Coding procedures are the last components of a coding scheme. They specify in detail which steps to follow in order to identify the target units in the data. Coding procedures must be specified as detailed as possible not only because they tell a researcher what to do, but especially because they represent what could be called the 'mechanised' component of a coding scheme. By 'mechanically' is intended here not 'operable by a computer', but rather that a researcher unfamiliar with the underlying framework and the target phenomena, and 'blind' to the final aims of the analysis should be able to code the data.

5.3.6.2 Narrative description of use

The coding procedure's aim it to enable a researcher to identify positive instances of the 6 types of learning processes described above (section 5.3.3 and Table 1). The identification of positive instances is made through indicators that are of two basic forms: references to aspects, concepts or cases, and keywords and key phrases. This coding scheme distinguishes between primary and secondary indicators. This distinction does not entail a differentiation in terms of importance, but rather is made to permit an algorithmic application of the coding scheme. That is, primary indicators should be identified first, and if they can be identified in a unit, then a coder should look for secondary indicators. The primary indicators are the following: references to an aspect, to abstract knowledge (concepts) or to a case. The secondary indicators are the following: reference to another aspect, case or abstract knowledge (concept), and keyword and key phrases. If a unit contains both a primary and one or more necessary secondary indicators, it can be assigned uniquely a coding category (for a list of coding categories, primary and secondary indicator, see table 3).

	processes (coding category)	primary indicators	secondary indicators
1	**relating aspect and concept**	reference to an aspect	reference to a concept
2	**relating concepts**	reference to a concept	reference to a concept; indicators of relationing
3	**relating aspects**	reference to an aspect	reference to an aspect; keywords indicating relationing
4	**relating cases**	reference to case	reference to another case; keywords: "similar", "different", "is like"
5	**abstracting similarities/ differences**	reference to other cases	reference to other cases; reference to an aspect that renders cases similar/different
6	**abstracting principles**	reference to whole case	reference to some abstract principle/type
7	**analogies**	reference to another case	use of its structure (interpretation/decision /solution)

Table 3. The coding categories and their primary and secondary indicators.

Most learning processes involve aspects of the case, and a first identification of a unit that may be one of the positive instances sought is to check whether the isolated unit contains a reference to an aspect of the case. In an ideal case, an aspect is referenced with the same term as used in the case description, but alternative terms (e.g. "she is in pain", "she is suffering") that clearly reference an aspect of the case are also acceptable.

Identifying a reference to an aspect in the unit is the first step towards checking whether that aspect is conceptualised, is related to another aspect, or is emphasised as one of the conditions of applicability of a concept. The distinction between these categories requires identifying further references in the same unit: to another aspect or to a concept.

Keywords and key phrases play an important role in this stage because these words or phrases are indicative of relationing. For example, the presence of keywords indicating a causal relation ("so", "because") in a unit is an indication that a relation has been established between two aspects. Similarly, keywords are indicative for a relationing between an aspect and a concept ("[concept C applies] because [of aspect A]"]. The category of 'verifying/formulating conditions of applicability of concept' does not strictly rely on keywords for their identification,

though some keywords can be useful. This category applies if it is evident in the proposition that the students struggle to apply a concept or when they generalise from the aspect.

Another primary indicator is a reference to another case. By this is meant the case as a whole, not a reference to an aspect of the case (though aspect references play a role as secondary indicators). The interest of these references lies in identifying learning that occurs across cases, such as when students compare cases, or rely on their understanding of one case to interpret another. The central secondary indicator is hence a reference to another case. The cases used as learning material or episodes in the public domain, or private ones, may be referred to. Further essential secondary indicators are terms that show that indeed the cases are being compared or that some form of relationing is occurring. Certainly keywords, such as "is like" or "is different", or key phrases such as "in this case here ... while in that case there..." are very valuable indicators of this kind, though more implicit comparisons can also be used for an identification. A further distinction is made once a unit is positively identified, i.e. contains primary and secondary indicators: whether there are explicit references to a specific aspect that renders the cases similar or different. The presence of such a reference is an indication that the comparison resulted in the abstraction of a domain-specific dimension (e.g. active versus passive euthanasia). Knowledge so abstracted becomes part of a domain-specific vocabulary used to memorise cases as well as encode future situations. If such a reference is present, the unit is classified as category 4 (relating cases) and 5 (abstracting similarities/differences); if not, only as category 4.

The indicators for an analogy are keywords or phases that show that a student reuses a solution or interpretation of one case to solve or interpret another. That reuse must be explicit, i.e. expressions of similarities are insufficient for a positive identification of analogies. Analogies are quite easily evidentiable because they involve comparisons and abstractions, each of which can be identified through keywords, as described above.

The third primary indicator is a reference to abstract knowledge. Abstract knowledge includes concepts pertinent for the discussed case as well as references to the 'point' or 'story' of the case. Concepts and other abstract knowledge need to be distinguished however. If the unit refers to a concept, then it should also be checked whether a second concept is referred to in it. This second concept is a secondary indicator. Another secondary indicator is required to identify a unit as a positive instance of coding category 2 (relating concepts): a keyword or key phrase indicating a relationing between the two concepts. For example, two concepts may be referenced and said to be "in contrast".

The identification of references to a concept is a difficult task. This is because students' contributions often contain opinions, judgments or simply their view about the case (e.g. "they are treating her really badly"), and many of their views are only implicitly expressed in an utterance. Further, most concepts are expressed in mundane terms such as "a patient can chose what she wants", rather than in a domain-specific terminology (in this case, autonomy). The identification of a positive instance of category 2 should hence be carefully made.

Concrete indicators for the identification of a unit expressing the 'point' or 'story' of the whole case cannot be given, except that it is likely that the characterisation of a case occurs on the basis of mundane principles. An example of such an expression is "this is a 'he said – she said' situation" or also "this is a situation where all parties are constraint by [...]". These expressions represent embryonic conceptualization of the cases that may evolve into more sophisticated ones with practice.

5.3.6.3 Coding procedure in list form

Figure 8 presents the coding procedure in list form. The three main primary indicators (reference to whole case, aspect or abstract knowledge) are list items 1, 2 and 3. These indicators are to be identified first. After a positive identification through one indicator, no other primary indicators need to be checked. Rather, coding proceeds to identifying the secondary indicators. The list is the basis for an algorithmically application of the coding scheme. The categorization of unit can be carried out by: first, answering the questions posed, and, second, selecting a new sub-branch depending on an affirmative answer. If a unit is categorized, no further categorizations should be sought.

Coding procedure:

1. does the unit refer to the **case** as a whole? If yes:
   1.1. is there in the unit a reference to another case? If yes:
      1.1.1. does the proposition express a comparison between the cases (keywords indicating similarities, differences)?
         1.1.1.1. if yes: does the unit contain also a reference to an aspect that is emphasized as being present/absent in one or both of the cases. If yes => classify unit as category 4 (relating cases) and category 5 (abstracting similarities/differences)
         1.1.1.2. if no: classify unit as category 4 (relating cases)
      1.1.2. does the unit show that a solution/decision/principle/interpretation of one case is applied to another? If yes: classify unit as category 7 (analogy)

2. is there in the unit a reference to a specific **aspect** of the case? If yes:
   2.1. is there in the unit a reference to a concept? If yes:
      2.1.1. are the reference to the aspect and the one to the concept related causally (keywords: 'because', 'so'); or, is there an emphasis that a concept applies because of the aspect. If yes => classify unit as category 1 (relating aspects with concepts)
   2.2. is there in the unit a reference to another aspect? If yes:
      2.2.1. are the aspects explicitly related, e.g. causal relation or 'linear' relation? If yes => classify unit as category 3 (relating aspects)
      2.2.2.

3. is there in the unit a focus on **abstract knowledge** only? If yes:
   3.1. is the reference to a concept of a specific domain (ethics, law)? If yes
      3.1.1. is there in the unit a reference to another concept? If yes
         3.1.1.1. does the unit express that there is a relation between concepts (e.g. contrast, dependence, similarity). If yes => classify unit as category 2 (relating concepts)
   3.2. is the reference to a mundane principle/point? If yes => classify unit as category 6 (typifying/classifying case)

Figure 8. The coding procedure of the process coding scheme in algorithmic form. For a narrative description of the process coding scheme, see section 5.3.6.2.

Coding examples

Figure 9 and figure 10 represent two examples of how the process coding scheme is applied.

Example unit 1: "*...this is the difference; here she asks to be detached from the ventilator, while in that case she is actually asking that doctors give her an injection*"

- the unit refers to the case as a whole (1.)
- it contains a reference to another case (1.1.)
- it contains a reference to a specific aspect (1.1.1.)
- the unit is classified in category 4 and 5 (relating cases, and abstracting a similarity/difference)

Figure 9. An example of classifying an utterance into categories 4 and 5.

Example unit 2: "*...they weren't trying to relieve suffering, but they were trying not to harm her*"

- the unit doesn't refer explicitly to the case as a whole or to a concrete aspect of the case
- it refers to some abstract knowledge (3)
- it refers to some ethical principle ('relieving suffering', 'not harming') (3.1.)
- it refers to more than one principle (3.1.1.)
- it expresses a relation between the principles ("but", indicating a contrast between principles) (3.1.1.1.)
- the unit is classified in category 3 (relating concepts)

Figure 10. An example of classifying an utterance as one where concepts are related (category 3)

5.3.7 Summary

This concludes the description of the first analysis tool: the process-coding scheme. That scheme targets learning processes in students' utterances, and it is the basis for two descriptions: first, a quantification resulting from the application of the scheme will give insight into what learning processes are commonly used when students learn with cases. And second, the occurrence of learning processes is the basis upon which to infer what knowledge is acquired, i.e. to infer the learning products.

The analysis of learning processes permits a description of learning as the gradual and relatively slow acquisition of new knowledge or modification of existing one. However, under certain conditions, people may learn through a radical reorganization of their existing conceptual knowledge, a phenomenon known as conceptual change. That phenomenon is the target of an analysis scheme, presented next.

5.4 Evidencing conceptual change

5.4.1 Introduction

Conceptual change is the quite radical reorganization of knowledge, and is one of the most effective forms of learning. It contrasts with other forms of learning that are more gradual, such as the form captured by the process analysis. The identification of conceptual change is sometimes cited as the most reliable means by which it can be ascertained whether students have solved a problem correctly. The assessment would not only focus on a correct solution, but on how students describe the problem situation. Conceptual change has occurred when that description changes as a result of a discussion, a teachers' intervention, thorough reflection, etc.

The identification of conceptual change relies on findings on how the interpretation of problems (or cases) and their aspects are modified by an underlying change in the conceptual structure. It rests on the analysis of terms used to describe the problem situations, and often it can be readily identified. For example, conceptual change is sometimes accompanied by expressions indicating understanding (e.g. "I got it!", "ah, this is how it works", cf. Roschelle, 1992). The present section will reiterate shortly the underlying theory of conceptual change (described in detail in section 3.3.5.3), and present a common way to identify conceptual change. This way is sufficient for analysing the discussions of study 1 (chapter 6).

5.4.2 Evidencing changes in problem descriptions

It could be said that identifying conceptual change is a quite direct for of identifying learning. What is assessed is whether students are able to see correctly the structure of a problem; and seeing the problem correctly entails to a large degree being able to solve it (cf. Gick & Holyoak, 1980; Hammond, Seifert & Gray, 1991; see also section 3.2.4). The identification of conceptual change, being of dual nature (i.e. an external and maybe also internal reorganisation, see section 3.3.5.3) relies on an analysis checking for correct descriptions of problems and the organisation of the problem elements.

This analysis has affinities with verbal analysis as described by Chi (1997). Chi introduces verbal analysis as a tool that can be used to evidence internal representations from people's description of problems. Clearly, the general analysis approach and analysis specifications are based on her earlier work on expertise (Chi, Feltovich & Glaser, 1981). In that work, she and her colleagues used descriptions of problems and descriptions of solutions to draw conclusions on experts' and novices' organization of knowledge, and the use of that knowledge in problem solving (Chi, Glaser & Rees, 1982). The analysis was based on the assumption that different internal representations would manifest themselves in the use of specific terms when describing a problem situation.

In short, verbal analysis rests on the assumption that people's descriptions of problem situations reveal their level of expertise and their knowledge structure (specifically the organization of their semantic networks). While verbal analysis is normally applied to transcripts of post-learning-session interviews, Roschelle, in his study on joint problem solving (Roschelle, 1992), applied it the dialogue itself. His use of verbal analysis rests on the assumption that is also central to the analysis in this thesis: namely that changes in the description of problem situations evident *during* a dialogue are indicative for learning. The analysis of students' description of a problem situation is indicative for, as Roschelle states, "the construction of a deep-featured situation at an intermediate level of abstraction from the literal features of the world" (pg. 5). The novel description is based on a conceptual change that occurred during the discussion and resulted in an understanding that is a "qualitative approximation to the scientific meaning" of a domain-specific concept (pg. 6).

The form of verbal analysis used in this thesis incorporates these basic assumptions. The analysis relies on the notion of structure as the all-encompassing conceptualisation of a problem that includes the interpretation of the aspects of cases. As has been described in section 3.2.5, the conceptualisation of a case is revealed as much by the use of a specific terminology on the case as a whole, as much as by the attribution of a role and relevance to the individual aspects of the case description.

5.5 The episode-focus analysis

5.5.1 Introduction

The next sections describe the coding scheme of the third analysis, the analysis of the relationships between the foci of a sequence of contributions (called 'episodes'). This analysis attempts to answer, in its most general formulation, the question why a certain topic is introduced into the discussion, and relies on a simple model of knowledge retrieval to answer it.

More specifically, the analysis answers the question about the effect of the students' pre-existing conceptual system on the introduction of knowledge items. It is assumed, on the basis of research on people's knowledge structure (e.g. Chi et al., 1981) that the activation of a specific concept activates a concept related to it. That is, when people solve problems of which they have some conceptual knowledge, they activate that conceptual knowledge, and the activation of one concept spreads to a concept related to it. The analysis also assumes that there is an alternative to the introduction of knowledge: semantic and associative relations. Indeed, other research has shown that semantic and associative relations between knowledge items (such as objects or properties of objects) play a significant role in introducing knowledge (cf. Herring, 1999). The analysis will answer the specific question whether it are relations between concepts, or semantic relation and associations that are mostly responsible for introducing a new topic into the discussions.

Research focusing on the topics of a discussion showed that contributions in a dialogue can be grouped into 'episodes' (or 'threads') that have a common focus (Shi et al., 2006). For example, a sequence of contributions may focus on verifying whether a specific fact supports a specific interpretation of a case. Once the argument on that topic is exhausted, students may switch to a new topic, i.e. they bring in a new knowledge element that is then discussed. The mechanism that triggers the introduction of a new knowledge element is the focus of this analysis.

There is still very little work analyzing the topic structure of dialogues. Hmelo (2003) analyses what concepts learners talk about and compares the resulting 'concept map' to a normative problem space. By problem space she means the map of the most relevant concepts to solve a problem. She then assesses how many of the pertinent concepts have been discussed. She derives an overall measure of 'coverage' of the relevant concepts, and interprets this measure in terms of the overall quality of learning. Shi et al. (2006) propose 'thread theory' (a thread being a series of messages on a similar topic or theme), a way to look at the topical relationships between the content of utterances. This work is entirely focused on the interactional properties of a discussion, and is cited here only as an example of the analysis of topical relations between messages.

The analysis proposed here is complementary to other kinds of analysis of discussion, such as analyses of argumentations. These analyses assume that the introduction of knowledge is guided by argumentation schemes. For example, people would introduce a knowledge item to make a claim or to provide supporting evidence for a claim. The analysis offered here proposes a different reason for the introduction of knowledge: simple retrieval of knowledge through relations between knowledge items. How an argumentation analysis relates to the topic analysis proposed here is however not yet clear (except that it is complementary). It is possible, for

example, that the automatic retrieval of knowledge plays a role in the activation of knowledge, but that argumentation structures act selectively on multiple retrieved items.

The sections are organized as follows: first, the assumptions of the analysis scheme are presented and its theoretical basis summarized. Then, the notion of episodes is described. These are the basis for the coding scheme that is presented subsequently. A description of the coding procedure concludes this section.

5.5.2 Assumptions and theoretical basis of the coding scheme

Underlying the analysis is the psychological concept of activation: exposure to a stimulus prompts the activation of knowledge entities related to it. Two kinds of relations are analysed here: relations between concepts, and semantic and associative relations. Semantic relations are relations between an object and the property of that object, but include also relations between two objects that are commonly associated. These relations are discussed now.

5.5.2.1 Relations between concepts

The role of relations between concepts in the use of concepts for problem solving has been well documented in the literature. For example, the studies on expertise showed that both experts and novices would proceed in solving the problem by retrieving related concepts (Chi et al., 1981). In physics, experts' knowledge system would, for example, consist of the concepts of force and the concept of gravity, and, once a problem situation is classified as being a problem of force, the concept of gravity is activated. Relations between concepts can be 'meaningful', labelled relations (Quillian, 1968), but also simply associations. Conceptual relations can also be relations indicating that the concepts are mutually exclusive. For example, an expert in physics would distinguish between gravity and 'normal forces', and knows that only one of these can be used to solve the problem. In ethics, where concepts are in contrast and indeed give rise to ethical dilemmas, the concepts may be related as being 'in opposition'. Concepts and relations of this kind would constitute the conceptual system of ethics, and the activation of a concept may activate also a concept that is in opposition to it. For example, when encoding a case of ethics, applying one concept may prompt the activation of a 'contrasting' concept, and the case would be understood as being an ethical dilemma.

5.5.2.2 Semantic and associative relations

By semantic relation is meant the relation between an object and its property or an object and another object with which it is commonly and in some way (associatively) related. For example, the object 'patient' may invoke the object 'hospital' (another object) or the property of 'being ill'.

Research on the topic structure of discussions has shown that semantic relations play a significant role in undirected discussions, such as informal chats. Herring's (1999) analysis of people's exchanges in computer-based chat rooms showed that new topics were introduced on the basis of simple semantic relations. For example, a new topic would be introduced on the basis of a property of a discussed object. Herring reports an example where an utterance mentioning the bald singer Sinead O'Connor was preceded by two utterances on hair and wigs (Herring, 1999; pg. 6, figure 3). Herring described this form of topic introduction as leading to 'topic decay', defined as the continuous decrease of the relevance of introduced topics to the overall, global topic.

It is possible that an object that the current topic of an episode is discussed within a different context (e.g. emphasising a different property). For example, if the role of physicians in a clinical decision is discussed in one episode and the high remunerations of physicians is discussed in the subsequent one, the relationship between the episodes would be also classified as 'semantic'. It would be classified in this way because what ties the focus of one episode to the subsequent one is that both focus on 'physicians', but discuss issues related to different properties of physicians.

In sum, the following assumptions constitute the basis for the present analysis: first, the mechanism of activation can account for the introduction of a new topic into the discussion. Second, new topics are introduced on the basis of relations between concepts or on the basis of semantic and associative relations. The aim of the analysis is to investigate whether the students' conceptual system is primarily responsible for the introduction of new knowledge into the discussion.

5.5.2.3 Segmenting a dialogue into episodes

Segmentation of dialogues into sequences of utterances with a common focus occurs frequently in dialogue analyses. In the DISCOUNT scheme (Pilkington, 1999) such sequences are labelled 'episodes', and this term is used here (as described above, Shi et al., 2006, call these sequences 'threads'). The scheme, which is quite frequently used or cited in dialogue analysis research, is

specifically aimed that educational dialogues, but, in contrast to the analysis approach of this thesis, focuses on their exchange structure, not on knowledge or cognitive structures evident in a dialogue. It hence provides here only a most general framework for the analysis.

Episodes are defined as sequences of utterances that focus on a similar topic. In the analysis presented here episodes are determined exclusively from the ideational content of utterances. This form of identification diverges from others, including the one used by the DISCOUNT scheme where episodes are identified on the base of the exchange structure.

Episodes often emerge naturally from dialogues since topics or pointers to topics introduced into the discussion prompt some response from peers until the interest or knowledge of that topic is exhausted or the overall intention of the exchange(s) constituting the episode is satisfied. Episodes are often identifiable because exchanges close: for example, a question – answer exchange is closed once the answer provides by a peer is deemed as satisfactory by the question-poser. An argument exchange may close when agreement is reached, whether it is on a specific claim or whether there is agreement on an unbridgeable difference between, for example, interpretations of problems.

Segmentation into episodes may return singletons or may reveal overlap of episodes. Singletons, episodes consisting of one utterance only occur when a topic does not prompt interest or knowledge by peers or when the focus of another episode, running in parallel, is deemed more important. Dialogues characterised by many singletons are considered being unproductive and do not constitute acceptable collaboration or cooperation. However, singletons and overlapping episodes are quite frequent in dialogues using technology supporting quasi-synchronous communication, such as a chat (Herring, 1999).

Segmentation into episodes based only on the focus of utterances is complicated by the requirement that it needs an assessment of the semantic distance between the focus of utterances. However, as will be described in the conclusion section of this chapter, in practice this difficulty did not present an insurmountable obstacle.

The problem with semantic distance is its subjectivity: what is information or knowledge pertinent to the current topic for one person may be less so for another; further, topics that are semantically distant may be introduced into the dialogue for certain dialogical moves (such as irony). The problem of the subjectivity of semantic distance can be addressed methodologically by considering a larger unit of analysis than just the utterance when identifying episodes. Several utterances may need to be taken into consideration to determine with acceptable probability what the topic under discussion is. The following example (figure 11) illustrates this requirement.

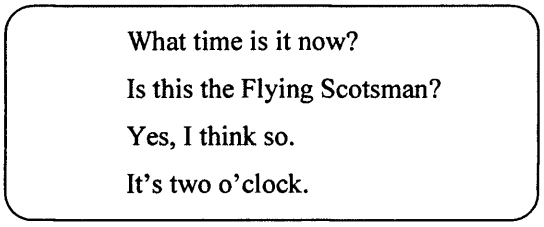

Figure 11. A sequence of utterances that may seem like nested and unrelated episodes, but are a single episode (from Pilkington, 1999).

A further example of this methodological requirement is when semantically distant topics are used for certain dialogue moves: semantically distant topics may be brought in to emphasise a point. The distance is, in these cases, merely superficial, while there exist structural similarities between the two topics.

While semantic distance constitutes a problem for dialogue analysis, it is also an opportunity: the subjectivity of semantic distance permits insight into people's knowledge bases. In particular, relations between topics reflect the students' conceptual systems (mundane and domain-specific). For example, if someone talks about the Eiffel Tower while the discussion is focused on London, it is obvious that s/he has incorrect knowledge, unless the topic is introduced as a specific dialogical move. The effect of relations, in particular conceptual and semantic ones, to infer discussants' knowledge structures is the basis for the analysis presented here. The following section described the coding categories in detail.

5.5.3 The coding scheme

To reiterate, the purpose of the analysis is to give insight into the role of relations between knowledge in introducing knowledge into the discussion. The specific question underlying the analysis is the following: to what degree do relations between concepts account for the introduction of knowledge, and to what degree do other relations (semantic and associative) account for it.

The analysis scheme and procedure are specified so as to answer this question. In its essence, the analysis consists of two steps: to check what the topic of a sequence of utterances (episode) is, and to identify whether the relations between the topics of episodes are conceptual or semantic/associative. The question will then be answered on the basis of how many relations between episodes are conceptual and how many semantic or associative.

The first step of the analysis is hence to identify the topic of an utterance. Topics can vary: they may be facts or actors of the case, they may be explicitly concepts themselves, or they may be other cases. Once the topic is identified, coding continues by checking whether the utterance does refer to one of the ethical principles/concepts pertinent for cases of euthanasia (see section 4.2.4 for the domain model). That is, the question whether an utterance refers to an ethical concept is answered only after the topic is identified.

The identification of a focus on a concept may be problematic because an utterance may refer to a specific ethical principle, but does not mention the correct term of the principle. For example, students may talk about the patient as someone "who should be able to make her own decision", and refer, by this expression, to the concept of autonomy. That concept is however not explicitly mentioned, and hence a coder needs to infer that the focus of the utterance is indeed on that concept. The expression 'points to' the concept of autonomy, but does not mention it.

The identification of a contribution as 'pointing to' a concept can be made on the basis of what terms and phrases are used in the contribution. For example, the term 'free' implies a reference to the concept of autonomy, the term 'protection' to the concept of beneficence, the phrase 'cannot harm' to the concept of nonmaleficiance. Identification of the conceptual focus is relatively unreliable because of the subjectivity of the decision, and identification is only made if there are sufficient grounds for it. And further, all classifications of 'conceptual focus' are presented together with the data analysis so they can be verified (see table 5 in chapter 6).

The second step of the coding procedure is to identify the episodes, i.e. to group utterances with a common focus. This is done by delimitating an episode between utterances that introduce a new topic. Each new episode is then numbered. The last stage is to identify the relations between episodes. If an episode does not refer to a concept, it needs to be checked whether there exists a semantic or associative relationship between the topics of the two adjacent episodes. If two adjacent episodes are both coded as referring to a concept, the relation between them is conceptual.

A last step of the coding procedure applies only to a pair of episodes whose topical relation has been identified as conceptual. In order to get a more detailed picture of conceptual relations, they will be additionally classified as 'supporting' or 'contrasting'. A 'supporting' relation is a relation between concepts that support the same view of the case (for example, autonomy and beneficence ('s good and gentle death') both support the patient's request for assisted suicide), while contrasting relations between concepts would lead to opposite views (e.g. autonomy and nonmaleficiance).

The coding needs also to account for the possibility that more than one concept are referred to in an utterance. These utterances should be counted separately and no relations between the previous and the subsequent utterances should be sought.

Impasses or blind alleys may also occur in the discussion: in the first case, the students cannot reach an agreement, in the second they are, at this stage of the discussion, unable to solve the problem. In these cases, participants may reconsider the task demand, return to an earlier question, or resort to different strategies. Topic switches of these kind represent very large semantic distances, or, in the case of a return to the task demand, no semantic relations at all. These relations will be coded as appropriate.

The next section presents the coding scheme in list form.

5.5.4 Coding categories and coding procedure

Here the coding categories (focus) (figure 12), coding categories (relations) (figure 11) and the coding procedure (figure 14) are presented.

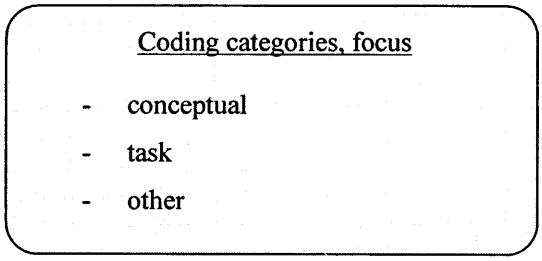

Figure 12. The categories according to which the focus of an episode should be classified

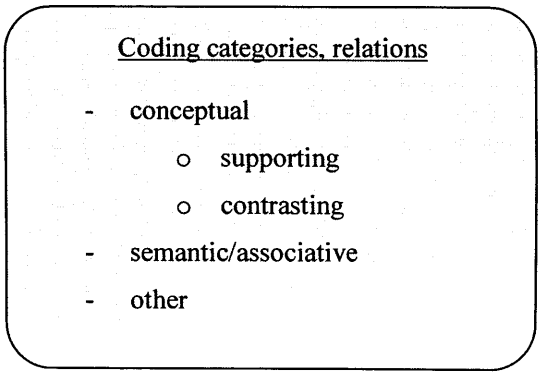

Figure 13. The categories according to which the topical relations between episodes should be classified

Coding procedure

1. identify topic of utterance
2. identify episodes: an episode is delimited when there is an evident switch of focus between one utterance and a subsequent one
3. identify concept pointed to or mentioned in the episode, using the following criteria: keyword(s) or proposition(s) representative of conceptual focus or concept
   - 3.1.1 if there are relations between concepts explicit or can be reasonably inferred from utterance, then they should be labelled as such
   - 3.2 if the focus is on a case, identify concept pointed to
4. if more than one concept is referred to in an utterance, report and count it separately. No relations between the previous and subsequent utterance should be identified
5. identify relations between an episode and the immediately previous episode, using the following categories:
   - 5.1 conceptual (i.e. relation between concepts). To identify relations, see the domain model (figure 7, page 108). Then, classify the relations into:
     - 5.1.2 contrasting
     - 5.1.3 supporting
   - 5.2 semantic/associative
   - 5.3 other

Figure 14. The coding procedure for the episode-focus coding, in algorithmic form. The steps to be carried out in the order presented in the figure.

5.5.5 Summary

The aim of this last coding scheme is to answer the question about the role of relations between concepts and other relations (semantic, associative) in introducing new knowledge into the discussion. This question is a specialisation of the thesis question on the mechanism of learning: within the activity view of learning, the introduction of knowledge into the discussion can be seen as a mechanism, one that is particular to the collaborative context of learning. The question

can be answered in this context better than in other more artificial contexts that would, for example, ask people to think aloud or give reasons for the deployment of knowledge.

This analysis scheme should be seen as one of the few attempts to investigate why certain knowledge is deployed in a discussion. As described above, most research on collaborative learning focuses on particular 'procedures' typical for collaborative learning such as argumentation. These schemes are deemed to be responsible for the deployment of knowledge. For example, a student would mention a fact of a case in order to 'support a claim'. The deployment of knowledge is, in this research approach, subordinate to a collaboration-specific mechanism. The analysis presented here is complementary to that research approach.

Chapter 6
Analysis and characterisation of the small-group discussions

6.1 Introduction

The following sections will now present and discuss the analysis of the 2 small-group discussions. The most extensive analysis targets learning processes evident in utterances, i.e. it targets the processes employed in the construction of a conceptualisation of the cases, a phenomenon that is called, in this thesis, the structuring of the cases. Chapter 3 identified what processes are likely to be used to structure a case. A second analysis aims to evidence conceptual change, a form of learning that, in contrast to the relatively slow and gradual construction of an abstract representation, is a radical reorganisation of conceptual knowledge. A last analysis attempts to give some insight into the role of pre-existing knowledge on the introduction of a new topic into the discussion. The analysis relies on the identification of exchanges of a common focus (called episodes), and the identification of relations between episodes.

The interpretation of the analyses, augmented by a description of a missed learning opportunity, is the basis for presenting a qualitative characterisation of the learning outcomes of the discussions.

6.2 Some characteristics of the discussions

The discussions consist of 171[9] (group 1) and 198 (group 2) utterances. Only in group 2, at the beginning of the discussion a facilitator is present (24 utterances (11.9%)). Most utterances are on the cases themselves, though a small number discusses issues tangentially related to them (e.g. the role of law in euthanasia cases, different policies on euthanasia in other countries, etc.).

In both discussions, the dilemma is explicitly described towards the end of the discussions (line 103 in group 1, figure 23; line 164 in group 2, figure 25). That is, both groups correctly instantiate the cases as situations where ethics principles contrast, and mention this dilemma explicitly. In group 2, the contrast between the principles is understood and explicitly mentioned as the output of the discussion, to be brought to the plenary discussion (figure 26). The most conspicuous aspect of the general character of the discussions is that the students only superficially and unsuccessfully carry out the task set by the tutors. The discussion of group 1 is characterised by multiple failed attempts to use the scheme of practical reasoning. For example, they have marked difficulties in applying the categories 'facts' and 'values' on the case (see figure 15). Group 2 seems to dismiss the task from the beginning, i.e. the students in this group do not try to frame the aspects of the cases within these categories. Neither of the groups, though, rejects the task explicitly. No post-session interviews were conducted to clarify the reasons for not following the task, but it can be speculated that the students do not see any value in using these categories, or that they think that the reasoning scheme is unhelpful in understanding the cases.

In place of the task set, the students pursue their own goal: to argue against the judges' decision. The students disagree with the decision, because it denied the patient the assistance needed to take her own life and 'end her suffering', an assistance both patients have requested. As will be explained more in detail later, the students' disagreement results from sympathy with the patients' plight as well as from their view that the principle of autonomy (the freedom to choose) should be given more prominence in euthanasia cases (see figure 16).

The discussion is partially devoted to identifying the reasons for the judges' decision, but especially to substantiate the students' view of the situation in particular and of cases of

[9] Non-verbal actions, such as 'all students writing' have been assigned a sequential number for practical purposes. These were subtracted from the total number of lines to derive the total number of verbal contributions.

euthanasia in general. In doing so, the students identify the dilemma in the cases, i.e. they instantiate the cases as examples of a current ethical problem.

40	**I**	**yeah. ..... so, ... legally, the values are,... ... that the UK is not ready to sanction the idea of assisted suicide**

Figure 15. This utterance of student I (group 1) shows her difficulty of applying the category 'values'. It shows a somewhat 'forced' application of the category of 'values' and confusion with the meaning of 'legal'.

9	**E**	**and maybe it's quite honourable, I'm not sure {if?} even got to a point * he could have just put sleeping pills in her drink. ** would ever have done *** and if they hadn't gone through all of this then * {talking/token of/to?} died the way she'd wanted to. {It's really sad? actually?} ***

Figure 16. This utterance is an example of the students' sympathy for the patient. Student E (group 1) argues that it would be acceptable if the patients' husband helps her to die.

In general, both groups identify the ethical dilemma in the cases, and relate the case aspects correctly to the relevant concepts. The identification of the dilemma occurs gradually: individual students bring in different viewpoints sanctioned by one of the pertinent ethics principles that are then argued against by their peers. This characteristic is puzzling because the students do, as a consequence of the value they place on the principle of autonomy, firmly side with the patient. The arguments for and against the judges' decision are hence not made on the grounds that some students agree with the judges. Rather, it appears that some students take on temporarily the position of the authorities, in order to make an argument. In a sense, they take a 'devil's advocate approach'. The result of temporary position-taking is that the case is analysed more thoroughly: instead of only identifying those features of the case that support the students' personal viewpoints ("she wanted it", "she was very sick"), other aspects are discussed such as the implications of relying only on the principle of autonomy. In addition, relations between concepts are discussed as well. For example, they discuss the constraint the principle of universalisibility places on all other principles, and, clearly, they discuss how the principle of autonomy conflicts with duties of a doctor. It can be argued that the temporary position taking results in a more balanced abstract representation of the cases. That is, the cases are represented as instances of an ethical dilemma, not as instances of a single specific principle.

The following section presents now the first analysis, the analysis of cognitive processes as they can be inferred from the students' utterances.

6.3 The process analysis

6.3.1 Introduction

The aim of this first analysis was to identify cognitive processes in the dialogues. The results of the analysis are presented, first, as a quantification showing which processes occur most frequently; and second, to illustrate how learners use information and knowledge to construct the abstract representation of the cases.

Chapter 3 has described those processes that research on learning has identified as occurring when people learn with cases. These processes (see figure 4) are the bases for this first analysis. The analysis searched in each of the units of analysis (normally the proposition unit) for a process. It attempted to classify each identified unit into one of the coding categories (that correspond to the processes), and, if that classification fails, the unit is not coded.

The first section will present a quantification of the discussions in terms of how often a process occurred. The section will also discuss how to interpret the quantities. The subsequent sections will presents each of the processes. Examples for each will be given, as well as their significance for learning discussed. The last two sections will present the processes that are not evident, and speculate about the reasons for their absence.

6.3.2 Quantitative results

In this section, the results of the analysis are presented quantitatively in order to give an overview of which processes occur more or less frequently.

The total number of utterances was the following: in group 1, 168 utterances were considered for the analysis, in group 2, 155. In the transcripts, the total number of lines is 186 and 197, respectively, but for practical purposes, separate lines were used to report non-verbal contributions, and these contributions were not analysed. There were 18 of these lines for each group. The contributions of the facilitator in group 2 (24 lines) were also subtracted, resulting in a total of 155 students' verbal contributions to be subjected to the analysis.

Of these total verbal contributions, 23 were identified as positive instances in group 1, and 26 in group 2. As a percentage of the total of verbal contributions, 13.6 % of them were positive instances in group 1, while it was 16.7 % in group 2.

Figure 17 and figure 18 are examples of utterances that were not identified as positive instances, i.e. none of the utterances could be classified according to one of the coding categories.

150	C	a doctor is gonna help her to die, and how is she's gonna {find?} this doctor, because I wouldn't ...
151	P	(interrupts) and how's this doctor not gonna get convicted for anything if he helps her to die,
152	C	I wouldn't
153	E	He would get convicted because it's against our law, but in the Netherlands, there's a machine that {kills someone?} and there's a button ...
154	C	yes, but who's going to press that button
155	E	well
156	C	that's the thing, the responsibility of that person. I wouldn't want to be held responsible for like killing a person. [4:47]

Figure 17. An exchange (of group 2) where neither of the utterances were identified as positive instances of any of the coding categories. None of the utterances contains any reference to an aspect, nor to an ethical concept. The exchange is about legal implication of active euthanasia.

2	E	so how did she, how did she, ... she's {having? on her?} ventilation, which meant that (looks at sheet) she's going to {trick?} so she wanted additional help, so what did she want, an injection, or ...?
3	C	I think she wanted an injection.
4	E	**
5	C	(approving) mmh
6		(all three look into the hand-outs)
7	E	{but? that?} she wanted a treatment to be able to do it.

Figure 18. This exchange (group 1) focuses on an aspect, but no concept is explicitly mentioned in it. None of the utterances has been classified as a positive instance of one of the coding categories.

The percentage of utterances that could be classified according to one of the process categories appears to be quite low (13.6%, group 1 and 16.7%, group 2). However, these frequencies need to be interpreted within the observation that processes may be distributed over several utterances or that many utterances are related to a positive instance as responses, questions, etc. For example, an utterance may consist of an affirmative statement ("yes", "I agree") responding to an earlier utterance that was classified as one of the processes. In these instances, only that utterance was counted (see figure 19). Further, a process may be repeated within an exchange (see figure 20), and also in this case only one instance was classified.

More in general, in the discussion exchanges with a common focus (called episodes) are evident, a characteristic that is typical for educational discussion, and will be further investigated within the episode-focus analysis (see section 6.4). Episodes may consist of up to 15 or more contributions. If within such an exchange one utterance could be classified as one of the process coding categories, only that utterance was counted. This procedure of quantification explains the low number of coded utterances.

57	E	that she has made an informed decision *** she was, she was (points to his head)
58	P	... she was stable ...
59	E	yes
60	C	she was unstable ...
61	P	she was stable at the point when she wrote the letter [6:55]

Figure 19. An exchange (of group 2) counted as only one instance of the process of 'relating aspects and concepts'. The students discuss whether the patient was able to make an informed decision. The concept ('autonomy') is referred to in the expression 'informed consent'.

112	I	so what about her?
113	C	yeah, I think she just wants to end her suffering...
114	E + I	... yeah, yeah...
115	C	... that's my life, I should be allowed to end my suffering
116	E + I	yeah [13:30]
117		(all three writing, 20sec)
118	I	and the husband ...
119	E	(interrupting) was that her value judgment... that, ... that she should be allowed to end her life?

Figure 20. An exchange (of group 1) showing a repetition (line 115) and confirmations (lines 114 and 116) of the same process ('relating aspects and concepts'). Because of the repetitions and confirmation, the exchange is counted as only one instance of the process. In the exchange, the students justify the patients' demands by referring to the concept of autonomy.

Before presenting a more detailed picture of the processes, the role of the quantifications in this chapter that focuses on providing a qualitative description of learning, is shortly discussed. One of the aims of the analysis, and indeed a precondition for deriving further conclusions from the analysis, is to show that learning with cases can be conceptualised in terms of structuring. That is, that the essential (implicit) goal of a case-centred discussion is to construct an abstract representation of the cases. The processes that construct that representation as well as the information and knowledge employed to construct it are identified through the analyses presented in this chapter. Within this aim, the frequency of positive instances is of importance: a very low frequency means that the proposal to conceptualise learning with cases in terms of structuring does not capture enough of the data to warrant the claim that indeed learning with cases is structuring. That is, a low frequency of positive instances means that the construct sought is not sufficiently present in the data. Since the overall conception of learning with cases is operationalized in the coding categories, a low frequency of positive instances may derive from a lack of mapping between the conception and the coding categories, rather than the conception itself.

Within this question, the quantifications about the frequencies of positive utterances (together with the observation that many processes are embedded within other utterances that relate to the positive instance) shows that the conception of learning as well as the coding categories do capture many important phenomena of learning with cases.

The quantification serves to show which processes occur most frequently, less frequently or are absent. From a quantitative representation, conclusions about what processes, and what forms of learning occur typically when people learn with cases, can be made. In this sense, the quantification serves to support qualitative conclusions about the character and learning outcomes of the discussions. The more detailed picture on the number of occurrences of specific processes is given now.

Table 4 reports the number of utterances that were classified as positive instances of one of the target phenomena, by group and by target phenomenon (process). The table shows that the process of relating aspects and concepts is the most common one (51%), while the processes of relating cases and relating concepts occur also quite frequently (24.5% and 12.8%, respectively). The processes of abstracting principles, analogies and relating aspect occur only infrequently. In the next section, each of the processes will be presented in detail.

	processes		group 1	group 2	total
1	relating aspects and concepts		13	12	25 (51%)
2	relating concepts		4	2	6 (12.2%)
3	relating aspects		1	-	1 (2%)
4	relating cases	without abstraction	-	4	4 (8.1%)
5		with abstraction	4	5	9 (18.4%)
6	abstracting principles		-	-	-
7	analogies		1	3	4 (8.1%)
	total		23	26	49

Table 4. The table reports the total and percentage of all utterances that could be classified within one of the coding categories. The process 'relating cases' is divided into two subprocesses: 'with abstraction' and 'without abstraction' (of a common or distinctive feature). The total number of utterances indicating 'relating cases' is 13 (26.5%).

6.3.3 Positive instances

In the following sections, the processes will be presented in detail, illustrated with examples, and the significance of the processes for learning discussed. First, processes that occurred very frequently or quite frequently are presented, while a later section discusses the two processes that occurred only infrequently. The first two subsections present the two processes involving most significantly conceptual knowledge (relating aspects and concepts; relating concepts), then two processes involving almost exclusively other cases (relating cases and analogies) are presented.

6.3.3.1 Processes on conceptual knowledge

Relating aspects and concepts

Before describing this process, a note on seeing the application of ethics principles as a process of 'applying a concept' and a form of 'conceptualisation' is necessary. Ethics principles are understood to be and formulated as guidelines for behaviour, rather than being concepts in a traditional sense. However, they are similar to concepts in several aspects. For example, if a case is seen as embodying a specific principle, it could be said that that case is an instance for the principle, in analogy to the instantiation of an object through a basic-level concept. Also, ethics cases are interpreted according to what principles they represent and what principles are

applicable to them. For example, the cases under discussion are cases where the principle of autonomy, beneficence and other principles are applicable. The principles can hence be used as high-level abstract representations of the cases, similarly as concepts are abstract representations of objects.

The relationing between aspects and ethics principles is the most frequent cognitive process. Normally this process is evident when students focus on a specific aspect of the case, and check the aspect warrants the application of one of the ethics principles. Often the students engage in a shared decision on whether a principle applies. The reason for the high frequency of this process is that an aspect can be used to *justify* the application of a principle. For example, the fact that both patients' suffer in their current situation and have no remedy is possible that would reduce their suffering, warrants the application of the principle of beneficence ('good and gentle death', see figure 21). In the discussion, concrete facts function as 'data' that are presented to the group in order to justify the use of a principle for the conceptualisation of the case.

128	**E**	**but in this case (pointing to sheet) she was sick**

Figure 21. An utterance interpreted as the process of relating an aspect to a concept. Student E (group 1) points out that the patient is suffering, justifying the application of the principle of beneficence (good and gentle death).

45	**I**	**(interrupting) I think she was {of/in} stable mind.**

Figure 22. Another utterance interpreted as the process of relating an aspect to a concept. Student I (group 2) refers to the ability of the patient to make informed decisions, a precondition for applying the principle of autonomy

As described in 3.3.5.4, the significance of this process for learning is that learning about concepts involves determining the features that trigger their application. For example, the principle of autonomy is applicable only if the patient is able to understand her situation and to make decisions (see figure 22). Further, knowledge about concept features is essential for knowledge about relations between concepts, such as about their similarities and differences or their position within a conceptual structure.

The finding that students use single concepts or a conceptual structure while solving a problem is consistent with findings of novice problem solving strategies: it is typical for novices to adopt generally a hypothesis-driven strategy (Patel, Groen & Norman, 1993). Specifically, novices use their available general knowledge and check whether the data conform to it. Experts, instead, reason from data, i.e. they use aspects of the problem (such as symptoms) to retrieve general knowledge.

The relationing of facts with concepts may not terminate once the application of a principle is justified. Rather, it may lead to the acquisition of general knowledge: the students not only acquire knowledge about the specific case discussed, but also generalise over the case. For one, a concept may not only be checked whether it applies to this case, but also the more general conditions of applicability of a concept are formulated. This knowledge is considered here as a valuable by-product of the process of verifying the applicability of a concept.

Relating concepts

According to studies of the case method, case-centred learning promotes integration of conceptual knowledge and the relationing between concepts acquired in isolation (cf. section 2.2.3). Ethical (as environmental, political, etc.) cases or scenarios are useful to understand the relations (including conflicts) between principles, and the situations under which one principle may be favoured over another (Pata & Sarapuu, 2003). The role of cases in education in promoting integration and relationing is recognised and accepted by many practitioners and educators (Burgoyne, 2001). Cases are indeed frequently employed in education to raise the awareness of potential conflicts, problem and trade-offs (Guzdial et al. 1997). The framework to study learning with cases presented here hence is to be seen as a description of these educational observations in terms of cognitive processes.

As described in detail in section 4.2.4, the cases under discussion represent ethical dilemmas involving several ethical principles and their relations. These relations are relations of contrast and opposition, but also, in a specific situation, of convergence (see section 6.6.2). While it can assumed that the students possess some knowledge about contrasts between ethical principles (as indeed the exposure to publicised euthanasia cases has certainly prompted some reflection on and hence recognition of opposing principles), the discussion of the cases promotes the strengthening and clarification of relational knowledge. The major learning effect in these sessions is the refinement of existing conceptual knowledge (such as learning about the specific conditions of applicability of concepts) as opposed to the acquisition or the further integration of conceptual knowledge (for more details on this failure, see section 6.6). The discussion is interpreted as providing an opportunity to express the pre-existing conceptual structure. Evidences for this interpretation are utterances in figures 23 to 26 that are expressions on relational structures between principles that have certainly existed before the students came to the discussion session.

86	E	because in this case they were operating within the law and, say, they wanted to preserve life, but the weren't... but they weren't ... really ... they weren't ... they weren't really relieving suffering were they? ... which some people would argue {it would be?} ** preserve life. Some people they * doctors *** relieve suffering * preserve life, but {when?} they are suffering more {I mean?}then they should be able ** that's when **

Figure 23. Student E (group 1) formulates the dilemma between the principle of beneficence and nonmaleficence.

121	E	** I can't believe that there would be many people who disagree with it ..... unless they very strong religious beliefs [14:20] but, but, ... the decision on the end, I do bet that the people at the end didn't allow her to do it ... they didn't turn on their religious beliefs, but they turned on the fact that the whole British law would be changed.

Figure 24. Student E's (group 1) contribution embodies the dilemma between the principles of beneficence and universalisibility (elaborated later in the discussion)

128	E	you see, what you've got to bear in mind is that balance between trying to give the best care to the patient, you se, that's the thing.

Figure 25. Student E's (group 2) notion of 'balance' represents the dilemma between beneficence and autonomy.

140	I	we should bring up the two points. Wishes of the patient and preserving life ...

Figure 26. Student I (group 2) identifies the dilemma as 'the two points' (meaning the contrast between beneficence and autonomy).

6.3.3.2 Processes involving episodes

The previous sections described learning phenomena involving and affecting mostly conceptual knowledge; here the focus is on processes involving episodic knowledge. Most relevant work on episode-based problem solving and its associated learning mechanisms assumes that episodic and conceptual knowledge are distinct forms of knowledge, and indeed focuses often on the interaction between these forms of knowledge. For example, it is widely accepted that reuse of previous examples for problem solving leads to the acquisition of abstract knowledge, and specifically, knowledge that represents both examples (Ross, 1987). Further, it is also accepted that general knowledge plays a significant part in the search for and retrieval of episodes that may then be used for to solve current problems (cf. Kolodner, 1993). In sum, general and specific knowledge interact during problem solving and the memorisations of episodes as well as general knowledge acquired during reuse are forms of learning (see section 3.3.4.4 for an extensive discussion).

To further gain insights about learning outcomes, processes of learning that are deemed to be the most effective or the most valuable bases for further problem solving are identified. These processes are the relationing of cases and analogies.

Relating cases

While memorisation of cases or episodes is by itself considered a form of learning (cf. Schank, 1982), the reuse of episodes is crucially dependent on their organisation in memory. Episodes must be organised so as to permit efficient access and retrieval (Kolodner, 1993). Episodes that share features are normally grouped under a single header, with features not shared (distinctive features) providing a subsequent identification opportunity. Relating cases becomes a crucial mechanism in adding a case to the knowledge base, since it entails an assessment of similarities and differences, and an assessment of the relevance of the features, i.e. the identification of that or those features that represent the core of the case.

The two cases represent similar situations. Active vs. passive ('lack of action') intervention is the only specific difference between them. This difference assigns different weights to the principles of beneficence and nonmaleficence in making a decision, but the validity of autonomy remains unchanged.

Relating the cases, i.e. seeing the differences and similarities (figures 27 and 28), promote the reiteration of the application of the ethical principles, as well as the search for a solution that is applicable to both cases. It is a first step towards a deeper understanding of the principles.

The students also bring in cases of euthanasia that are in the public domain. These remindings also entail that cases are related. The students may use them to interpret the cases of Mrs. B and Mrs. Pretty, in a way similar to analogies. This is discussed in the next section.

161	**I**	**I mean, this is pretty * basically, she is refusing treatment, ... see, refusing treatment * to be actually killed is very different, isn't it.**

Figure 27. An utterance indicating the process of comparing the two cases and abstracting a difference. Student I (group 1) identifies the difference between the cases of Mrs. Pretty and Mrs. B.

34	C	**[shakes head in disagreement] ... there is the difference, because [looks at sheet], because, basically, Mrs. Pretty, no, Mrs. B ... it is passive and they could just switch off the ventilator, because basically they are keeping her alive, aahm, without her will (Peta nods approvingly), ..., whereas the other one (Mrs. Pretty) was actually actively given drugs to die. So that's why it's difference there, and basically, why we are using like artificial, we're using like drugs to keep people alive against their will, without letting them die [4:05] ... naturally**

Figure 28. Another utterance indicating the relationing between cases and the abstraction of similarities and differences. Student C (group 2) identifies the differences between the cases. She then interprets both cases as representing a similar core problem.

Analogies

Analogies go beyond determining similarities and differences of surfaces features of the cases: they lead to inferences and the transfer of structural knowledge between cases (see section 3.2.5.2). As is a common observation in analogy making, similarity assessments are normally not conscious, and often only the product of the analogy is conveyed.

In the discussion, the students are reminded of several other cases, and use these cases for various purposes. Remindings occur mostly in group 2, and some appear to have only a communicative rather than an inferential function. For example analogies are drawn between cases of personal experience or reported in the media in order to emphasise a personal view of the cases (see below for examples).

The two main functions of analogies are the following: to highlight a feature common to one of the discussed cases and another case and to introduce into the discussion knowledge (either a feature of the cases or the interpretation of the similar case). Other cases are used for structuring rather than for solving a case. It could be argued, hence, that what is observed in the discussion are not real analogies. However, a more extensive discussion on the differences between the reuse of other cases for solve a current one, and other uses (such as indeed emphasising a feature) is beyond the scope of this thesis. Nevertheless, it is assumed here that the use of structural knowledge of one case for another warrants the use of the term analogy.

As is known from the analogy literature, analogies serve to highlight common features of situations: mapping between the base and target separates shared from non-shared features (Markman & Gentner, 1996). This process highlights features common to both situations. Such a process of similarity comparison with subsequent highlighting of shared features occurs in the discussions: the students seem to use analogies to focus the discussion on a specific feature. Figure 30 shows an utterance where one of the contrasting relationships between principles is highlighted.

Analogies also serve the purpose of introducing knowledge, and this in two forms. First, by drawing attention to another similar case, the terminology or concept used to describe that case

is reused to describe the current case. As an example, in figures 29 and 31, the students introduce the concept of 'quality of life' by mentioning a similar case. While the students may have considered the concept already at earlier stages of the discussion, it is with this utterance that the specific terminology is introduced. Second, the students have knowledge about the verdicts in similar cases (figure 31). This knowledge can be used to reason about the possible consequences of a decision in the current case.

In sum, while analogies are recognised as being a powerful mechanism of problem solving, full analogies (consisting of similarity assessments, mapping and transfer) are rare in the discussion. However, remindings and processes associated with analogies contribute to the acquisition of knowledge: they involve the (normally implicit) assessment of similarities, and hence cases become related. Further, the introduction of a specific terminology increases the likelihood that this terminology and its associated concept will become part of the students' domain-specific vocabulary, to be used to encode future problem solving situations (for the role of encoding in problem solving, see section 3.2.6.2).

86	**I**	**I: my grandmother had terminal cancer basically, she couldn't move her head, just her mouth, and she was meant to be perfectly sound [mentally], she could follow..., she was really, really sound. I just remember that it was extremely frustrating to be mentally sound and not being able to [move]**

Figure 29. An utterance indicating a reminding. Student I's (group 2) reminding emphasises the plight of patients with terminal illnesses, highlighting the issue of 'quality of life'. Besides entailing the cognitive process of relationing the reference to the personal case may be seen as having a social function (increasing the students' status as an 'expert')

111	**I**	**because, I know someone who is a doctor and they had {referred?}, *** had a huge motorcycle accident he actually {had to have?} blood transfusions, * but when it actually came out ** [that he was a Jehovah's witness] , ** how can a doctor try to preserve life ***

Figure 30. A reminding about a case with a similar structure to the cases discussed. Student I (group 2) is reminded of a case representing the dilemma between autonomy and beneficence. The reminding emphasises particularly the principle of autonomy.

122	**I**	**yeah, ... there was a huge case in Canada a few years ago, were a father assisted his daughter, she was really very disabled ... and no quality of life [C and E seem to know the case] and he just suffocated her, and I think he got 12 years manslaughter.**

Figure 31. A reminding emphasising the notion of 'quality of life'. The 'outcome' of the case is also reported, and is used by the students to reason about the current cases.

6.3.4 Absent/infrequent process

The process of 'abstracting a mundane principle from the cases' is absent, and the process of 'relationing of aspects' is infrequent. Both these processes would entail the use of mundane structural knowledge: the process of abstracting principles is one where the story of the case is understood in mundane rather than domain-specific terms. Relationing of aspects would entail seeing mundane relationships between the aspects. These processes and speculations about the low frequency of their occurrence are presented in detail in the next two sections.

6.3.4.1 Abstracting principles

The particularity of this form of abstracting a structure from a case is that the case is cast in mundane terms. That is, domain-specific conceptual knowledge does play no role in structuring these stories.

People possess abstract knowledge embodying simple situations of their everyday experiences. For example, they may understand a legal case in terms of a conflict between two opposing narratives ("this is a 'he said, she said' situation"). Some researchers (e.g. Lakoff, 1990) have argued that this structural knowledge is used to understand more complex situations, especially in initial stages of learning a new domain. Simple relational knowledge, such as 'opposing', 'converging' or 'supporting' provides an initial meaning to complex situations, and may serve then as a building block to construct a more complex representation. Learning would occur when that initial structuring is challenged by data, i.e. when new aspects of a story contradict or cannot be coherently inserted in the structure.

The absence of this form of learning in the discussion can be explained by the fact that students' have some mundane knowledge about ethics (conveyed also in the lecture), and also have become acquainted with euthanasia cases that are in the public domain. That is, students possess a conceptual system of ethical principles, and they use it to conceptualise the case. This conceptual knowledge is clearly more adequate to conceptualise the cases than generic mundane knowledge.

Relating aspects

'Relating aspects' is a core phenomenon of structuring a case. It occurs when people see dependencies between aspects, such as a dependency between different actors of a narrative and dependencies between features of a case. Relationing of aspects occurs especially with complex cases and with cases where aspects vary within a dimension. For example, in business or management cases, certain features (such as profit, investment, size of workforce, etc.) are related, and the task of the students is to understand how they are related and of what kind the

relation is. Possible relations are causal or correlational (e.g. an increase in the workforce entails an increase in output, but maybe not in productivity). When trying to understand these relations, students act as, in a way, lay scientists, but, in contrast to a traditional form of learning science, students would learn about these relations by having available events that illustrate 'what happened when that action was taken'. That is, the abstraction of relations between case aspects is a task left to the students, rather than that relation being taught in a lecture.

The analysis identified only one utterance where aspects are related by mundane knowledge (figure 32). The example shows a relationing between the aspect of 'sound mind' (that is a necessary precondition for even considering the patient's request) and the patient's depression. In this specific case, authorities have argued that the patient's request may be tainted by her poor mental state. The student's comment criticises that argument by identifying a relationship between her physical and mental health.

170	**I**	**They think she can't decide on her own because she is depressed? Well of course she's depressed**

Figure 32. Student I (group 1) establishes a (causal) relationship between two aspects of the case: the patient's state of health and her state of mind. In this utterance, the student criticises with it the claim that the patient may not be able to decide for herself because of her depression. She claims that her depression results from the fact that her wish was denied by the authorities.

The absence of more instances of relationing aspects in these discussions is most probably due to the nature of the cases and the domain. The aspects of these euthanasia cases are few and do not vary within a dimension, except within the dichotomy of being absent or present (e.g. a patient may be of sound mind or not). In ethics cases, differences in aspects affect whether a concept is applied and whether an ethical principle is valid. Students do not need to model an ethics case, in the sense that they do not need to derive a dynamic description of the events, a description that would capture the essential relationships between the events and aspects. Rather, the main processing of cases is its conceptualisation and abstract representation. The low frequency of this process does hence not invalidate the hypothesis that this form of learning is characteristic for learning with cases in principle.

6.3.4.2 Beyond the case: acquiring general knowledge

Formulating the conditions of applicability of concepts

In 3 instances, the verification of applicability of a principle leads to the explicit formulation of its conditions of applicability. As described in chapter 3, in this analysis a distinction is made

between general knowledge and episodic knowledge. Memorising a case is itself learning, but general knowledge can be abstracted from the case. These abstractions can occur in two forms: first, reusing a case for problem solving forces some abstraction, a mechanism that is largely automatic; second, general knowledge can be acquired from one case. This form of learning requires either a specific task or an appropriate approach of the students. The exchange in figure 33 illustrates this latter form: students formulate explicit criteria for the application of a principle. The reason why this occurs in these cases is not known, but for certain the task does not demand these abstractions from them. It can be speculated that, being quite experienced learners, the students formulate general knowledge in order to improve memorisation of acquired knowledge or in order to increase the learning gains from the session.

The formulation of general knowledge occurs through the application of a concept to the case, and the subsequent verification of its applicability. Instead of terminating the verification of applicability, conditions of applicability may be formulated without explicit reference to the case (see figure 33). Similar to learning domain-specific factual knowledge (see next section), acquisition of this knowledge is not demanded by the task, and can hence be considered a by-product.

By explicitly formulating knowledge – specifically, the conditions of applicability of a concept – this knowledge is not tied to the studied case, and hence does not require the retrieval of the case to use it in a future problem solving situation.

129	**I**	**she was, but you know in this case I think if they said that this is legal then it could potentially open up a lot of, ... a lot of blur kind of, a lot of grey areas**
130	**E**	**...where to draw the line...**
131	**I**	**exactly**
132	**E**	**... someone has to be able to say and someone has to be able to write...**

Figure 33. This exchange of group 1 shows how the students explicitly formulate the conditions of applicability of the principle of autonomy (line 149).

Gaining knowledge about the legal and social environment

The acquisition of knowledge from processes stipulated by the framework is a substantial but only partial account of learning. This results from the strong theory-driven coding scheme that is applied on the data rather than the data giving rise to the coding scheme. Taking a more bottom-up approach to the development of a coding scheme that is able to capture more forms of learning is a future extension of this thesis. To give a sense of direction of such a future development, here a form of learning not captured by the coding scheme is described.

It can be observed that students focus sometimes on issues that are of relevance for cases of euthanasia, but fall outside their conceptualisation in terms of ethics. For example, the students focus on the role of law, the relationship between law and ethics, the role of ethics within society, or, as will be described in detail now, the roles and responsibilities of the main players in a scenario of euthanasia. A way to conceptualise this form of learning from the generic viewpoint on learning from which the model derives is difficult. The conceptualisation that captures this form of learning more closely is one of generalisation and relationing between aspects and a model of the workings of the society and culture within which ethical decisions are made. Specifically, the students see the cases as instances of generic euthanasia scenarios, and discuss the social and cultural environment within which such scenarios are decided. Such generalisations and relationing refers to conceptual and factual knowledge that is outside the domain of interest for this interpretation (ethics).

The form of knowledge acquired in this way may be called domain-specific general knowledge. It is knowledge about the actors/players (patient, relatives, physicians, government bodies, etc.), and their relationships and roles. In ethical cases, this knowledge includes knowledge about the locus of decision-making (who is, by law, required to make what decision), about the 'power' of actors, and about procedures of decision-making as prescribed by law, or by tradition and common practice. Such knowledge is at the basis of any attribution of responsibility. For example, knowing that physicians are bound to specific guidelines that are set by a government body may shift the search for values and motivations underlying a decision from the physicians to the government or its legal branch.

Correct knowledge about actors and their roles and relationships is not necessary to understand an ethical case, as indeed a case can be interpreted within a framework of ethical and moral values. However, it is essential knowledge for future physicians.

Acquiring such knowledge is a by-product of the discussion: generating an interpretation or judging the case does not necessarily require a discussion on such knowledge because the cases can be seen as simply reflecting or embodying ethical principles. Both groups discuss the locus of decision-making. Group 1 displays initially incorrect knowledge about responsibility of the judgement: they maintain, for a while, the opinion that the patient, Mrs. B, has been denied her wish because no physician was willing to assist her. However, they later speculate that a decision *for* Mrs. B would be problematic for legal reasons (see figure 34), because the law forbids killing in principle. In a later exchange, the students imply that one obstacle to waiving the validity of that general law is the difficulty to formulate a universally valid criterion for waiving it.

In contrast to group 1, the students of group 2 identify the GMC (General Medical Council) as the representative for the principles a physician must abide to (see figure 35). Their statements

on the 'contrariety' of the demands to the GMC towards physicians can be seen as expressing the ethical dilemmas of euthanasia cases. In a sense, the "contradictory" demands of the GMC stand in for the dilemmas, though one dilemma specifically is expressed without reference to the GMC (in utterance 128). It can be argued that the reference to the GMC is a result of the students' appeal to an authority once they realise that the cases present ethical dilemmas. The students seem to believe that a clear position of the GMC could absolve them from a personal dilemma if they would be confronted by a case of euthanasia in their future as physicians.

While more can be speculated about the students' knowledge (or lack of) and motivation, it is important to point out again that these exchanges show the acquisition or modification of domain-specific factual knowledge. This kind of knowledge is not only important for the understanding of the domain of ethics but also to practice as physicians. The peculiarity of its acquisition in this context is that it is not strictly necessary to understand the cases, but occurs rather as a by-product of the discussion. This form of learning illustrates the value of the case method: the inclusiveness and complexity of cases permits the acquisition of knowledge that a tutor has not foreseen; and further, its acquisition occurs in a simulated realistic context (which is indeed the one what fosters its acquisition) and thus may be integrated with conceptual knowledge.

107	**E**	**in this case I don't even know if it was ... the doctors' values that meant that ... she can have it in the end, it was more the court's value, wasn't it. ... 'cause I'm sure there were doctors who were saying, look I'll do it but it needs to be legal**
108	**C + I**	**Yeah**
109	**E**	**so I don't know whether they actually turned on the doctors' value judgment at the end because ...**
110	**I**	**(interrupting, looking at sheet) yeah, it doesn't mention actually anything about the doctors**
111	**E**	**yeah, I mean, it wasn't the case that she wasn't able to find a doctor who would do it**

Figure 34. This exchange of group 1 focuses on the locus of decision making in euthanasia cases. It is an example how the students gain general knowledge about the legal environment within which cases of euthanasia are decided. The group was initially of the opinion that no physician would help Mrs. B. However, the students then understand that the physicians are forbidden to do so by law, i.e. that the decision on euthanasia cases rests with the courts. The exchange is also evidence of the phenomenon of noticing through reanalysis (see sections 3.3.4 and 8.4.2.6)

120	E	what's the thing about in the GMC where it says to the doctor's, respect your patients' wishes...
121	I	so, is this (points to the sheet) not going against the GMC ...
122	P	that's what I thought...
123	I	... because the GMC explicitly says ..
124	P	... you know you've also got a right ...
125		(3 students looking into sheets)
126	I	it must have gone to the GMC [Mrs. B's case, here GMC refers to a panel of experts (doctors and/or judges)], ... it's such a high-profile case
127	P	no, but think about it, the doctors who are involved [in Mrs. B's case] are all qualified because of the GMC, so it [the GMC] is directly involved.
128	E	you see, what you've got to bear in mind is that balance between trying to give the best care to the patient, you se, that's the thing.
129	I	yes it's true, ** GMC ** contradictory * ...

Figure 35. An exchange of group 2 discussion on the locus of decision-making in euthanasia cases. This group assumes (incorrectly) that the responsibility for euthanasia cases lies with the GMC (General Medical Council). The students identify the GMC guidelines for physicians as being contradictory and representative for the ethical dilemma.

6.3.5 Summary and discussion

The overall picture emerging from the analysis is that much of students' effort is devoted to apply ethics principles onto the cases. The high frequency of the process of 'relating aspects to principles' (51%), normally occurring as a 'justification' (e.g. "she is of sound mind, and hence can make autonomous decisions") supports this interpretation. Their knowledge about the principles that are relevant to understand euthanasia cases is still rudimentary, but the cases give them the opportunity to refine that understanding: by relating the aspects to the principles, they acquire more specific knowledge about when the principles apply. Further, though the students have also some understanding about the ethical dilemma posed by euthanasia cases, only in the course of the discussion the conceptual system underlying the dilemma is explicitly related to the cases. As a consequence, the cases become concrete instances of the dilemma.

The students' learning is interpreted, in this thesis, as structuring: by using their existing knowledge about ethics concept, they impose a structure on the cases, and this structure is a high-level abstract representation of the cases. It is important to point out that the abstract representation is domain-specific not mundane. Indeed, the abstraction of a mundane 'principle' from the cases is virtually absent in the discussions.

Remindings of and analogies with similar cases, drawn from personal experiences or reported in the media, play an important role in generating this structure (the overall frequency of both processes is 34.6%). The conceptualisations and terminologies of other cases are reused to structure the cases of Mrs. B and Mrs. Pretty. For example, a student mentions the case of a patient who refuses blood transfusions for religious reasons that poses a similar problem for physicians as euthanasia cases do: how to help a patient against her wish. The remindings are not used to analogise, because solutions, in a strict sense, are not transferred between cases. However, some structural knowledge is reused to interpret the current cases.

A process that is notably infrequent (it occurs only once) is the relationing between aspects based on mundane knowledge. This process is distinct from the abstraction of a mundane 'story' or 'principle' from the cases in that it would not occur over the case as a whole, but involves only a few aspects. For this form of structuring to occur, a case must consist of many aspects whose relations can be identified through the events described. Euthanasia cases do not engender relationing between facts because they are not complex enough, nor do relations between aspects help much the understanding of the case as a whole. The rare example cited might hence be seen as relatively strong evidence that relationing between aspects is an important form of learning with cases.

Structuring occurs hence in the form of the conceptualisation of the case in terms of ethics principles. The application of the 'system of principles' gives each of the aspects, events and players a role in the narrative: who is responsible for making which decision, who supports or is against what decision etc. Clearer evidence for structuring has not been found. For example, the students do not gauge which of the events is the most important in producing another event or an outcome. But again, this form of structuring is not important for euthanasia cases, and its absence is not surprising.

Considered from the point of view of the learning gains, the overall character of learning is conservative, and new insights or the acquisition of new knowledge could not be identified. By structuring the cases, the students refine their knowledge about the conditions of applicability of ethics principles, and about their contrasting relations with other principles. However, as has been argued, and as will be shown with a further analysis (the episode-focus analysis, see next section), it is evident that the students possess some lay conceptual system about ethics, and further have been acquainted the euthanasia cases before the learning session. The cases were shortly mentioned in the lecture, but it can be reasonably assumed that the students have some knowledge about the dilemma that euthanasia cases pose to their profession, or their society. The discussion serves mostly to refine that knowledge, and to instantiate their lay ethics

principles with concrete cases. Their pre-existing conceptual system is strengthened, but not radically changed. In this sense, learning is conservative.

Through remindings and their use for the interpretation of the cases of Mrs. B and Mrs. Pretty students identify similarities and differences between the cases. They acquire, through these processes, knowledge about what features of euthanasia cases (and maybe other clinical scenarios representing ethical dilemmas) are relevant for interpretations and decisions. For example, they identify clearly that a patient must be able to understand her situation if she is to be considered an autonomous agent. Further, the students gain valuable episodic knowledge. That is, they acquire a knowledge base of cases of ethical dilemmas that will help them interpret situations they encounter in the future. These cases are organised around similarities and differences, and the identification of similar and distinctive feature will help them to retrieve the cases in the future and use them appropriately.

The next section will present the episode-focus analysis, an analysis on the topical relationships between exchanges with the same focus. The analysis will give further insight into the students' use of conceptual knowledge.

6.4 Episode-focus analysis

6.4.1 Introduction

In this section, the results, interpretations and conclusions from the episode-focus analysis are presented. As described in detail in section 5.5, this analysis attempts to illustrate the influence of the students' pre-existing conceptual structure on the introduction of a new topic into the discussion. It assumes that students possess a lay conceptual system of ethics, composed of ethical concepts and relations of opposition between them (e.g. the principle of autonomy contrasts with the principle of nonmaleficience). The assumption is made that the introduction of a new topic would occur on the basis of the activation of related concepts. So, for example, a student may introduce a topic relating to the principle of autonomy because in the previous utterances the focus was on the (contrasting) principle of nonmaleficience.

To contrast the role of the conceptual structure with the role of different relations (albeit the introduction of a topic would occur on the basis of the same activation mechanism), the analysis also assumes that semantic and associative relations between topics may be responsible for the introduction of a new topic. As has been described in section 5.5.2.2, the topic structure of dialogues may indeed results from semantic/associative relations between topics (Herring, 1999). The contrast the analysis highlights is hence between conceptual relations and semantic/associative relations between topics.

To reiterate, the analysis first groups utterances into episodes, i.e. utterances that share a common focus on a topic. Some research has indeed shown that dialogues demonstrate patterns where small sequences of utterances focus on the same topic (Shi, et al., 2006). The main task of the analysis is then to identify whether the relations between the topics of a pair of episodes occurring in sequence are conceptual or semantic/associative, the category 'conceptual' applying only if the topic of subsequent exchanges is conceptual (see details on coding in the next section). From the relative frequency of conceptual versus semantic/associative relations, the importance of the conceptual system can be inferred. The following sections describe how the analysis was carried out in practice, then report the result of this analysis, and then interpret and discuss the results.

6.4.2 The analysis procedure

The first stage of the analysis is the identification of the topic of an utterance; once the topic is identified, utterances focussing on the same topic are grouped into episodes. Subsequently, the analysis attempts to determine whether an utterance can be classified as referring to one of the ethical concepts pertinent for cases of euthanasia. This requires some interpretation of what the students are referring to when they talk about something, and clearly some uncertainties remain over that interpretation. Keywords, telltale signs and key phrases are helpful in this interpretation. For example, an utterance mentioning the term 'free' or the terms 'freedom to choose' is classified as referring to the principle of autonomy. An utterance expressing sympathy with the patients' plight and their suffering is classified as referring to the principle of beneficence (intended as 'good and gentle death'). As is evident from these examples, the inferences from an utterance of a reference to an ethics principle relied on some interpretative freedom. In order to permit a judgement on the soundness of these inferences, all interpretations are reported here (table 5). The table reports the utterance(s) of an episode (column 2 and 3, for group 1 and 2, respectively) that have been interpreted as referring to one of the pertinent ethical principles (column 1).

principle	*group 1*	*group 2*
autonomy	- they should let my wife, it's her life - she has to decide whether she wants to die - it's my life, I should be allowed to end my suffering - she wanted additional help - she is refusing treatment	- it depends what they want as well - in the GMC where it says to the doctor's, respect your patients' wishes... - when she writes that I don't want this - in an able state to sort of disagree with them - I think she was of stable mind - when she writes that I don't want this - she was stable at the point when she wrote the letter - she knew what she wanted - this one is talking (points to S1), no, she (points to S2) is talking, she (points to S1) is kind of talking.
nonmaleficiance	- doctors and husband cannot assist	
beneficence ('do good')	- you have to preserve life - laws must protect people's lives - doctors must preserve life of patients at any cost - they weren't reliving suffering - wanting to make anyone live no matter how ill they are	- trying to preserve the patient's life - you are supposed to prolong her life artificially - trying to give the best care to the patient
beneficence ('good and gentle death')	- she's suffering - she is struggling with it already, it is not like suddenly - she isn't suffering - really very disabled, no quality of life - debilitating, degenerative disease that is lethal, fatal - she wasn't gonna recover	- she was very active before and suddenly there was a quick change where she could do nothing - you have to be fed through a tube, a what type of life is that - what's the point of life - I wouldn't wanna be living like that - because that one is not moving - but then later on it got really bad
universalisibility	- they turned on the fact that the whole British law would be changed - cases where the doctors are going to push the button - it is difficult, you can see where it is going to be very blurred - who judges what is quality of life - if they said that this is legal then it could potentially open up a lot of, ... a lot of blur kind of, a lot of grey areas - where to draw the line - if they said no to this case, they couldn't say yes to any case ... - someone has to be able to say and someone has to be able to write...	- if we let her die, what, ... what is the consequence of that and how many other people will be able to come up with the same case - but it's all about where you draw the line - after this case they must have got so many other people just requesting the same thing - what if someone comes along and kills...

Table 5. This table reports all utterances interpreted as referring to one of the ethical principles pertinent for euthanasia cases. The second and third column reproduces the utterances, respectively, group 1 and group1, the first column the principle the utterances refer to.

If an episode cannot be interpreted as referring to one of the principles, it is classified as 'other' or 'task-focussed'. In such episodes students may talk about issues that do not strictly pertain to ethics, or may talk about the task.

These two additional categories are treated differently in the analysis. Episodes of the category 'task-focussed' are not included in the subsequent analysis of the relations between the topics of episodes. The analysis is indeed only interested in relations between the topics of a pair of episodes occurring in sequence, and episodes focussing on the task don't have conceptual or semantic/associative relations with the topics of a previous or subsequent episode.

In episodes of the category 'other' students talk about issues that come spontaneously into their minds when hearing about a topic, but those issues have no or only marginal importance for the interpretation of the case in terms of ethics concept. For example, students may talk about the law, or may talk about the relationship between the main players in euthanasia cases. In one example, the students talked about how different countries had different policies on euthanasia, without however discussing how these different policies relate to different ethics principles. In other exchanges, the students talk about legal issues law or about the players' relationships. These are certainly interesting topics, but they are not helpful in interpreting the cases from an ethics perspective.

The last step of the analysis is to identify whether the relations between a pair of episodes in sequence are conceptual, or semantic or associative. Again, only episodes categories as 'conceptual or 'other' are included in this subsequent analysis. Conceptual relations can only be identified in a pair of utterances that both refer to a concept. Semantic/associative relations can exist between pairs of episodes where one refers to a concept and the other doesn't, or where both don't refer to a concept. Conceptual relations are further distinguished into 'contrasting' and 'supporting' relations. Contrasting conceptual relations are between principles that would support a different judgement of the cases. For example, a judgement based on the principle of autonomy would grant the patient her wish to die peacefully, while a judgment on the principle of nonmaleficiance would not. Supporting conceptual relations are between principles that support the same judgment (e.g. nonmaleficiance and beneficence, intended as preserving life at all costs). The significance of this distinction will be explained in the discussion section.

It should be pointed out that a large amount of episodes referring to an ethical concept entails a large amount of conceptual relations between episodes: the more there are episodes referring to a concept, the more likely it is that pairs of 'conceptual' episodes are found.

6.4.3 Results

This section presents now the results of the analysis. Table 6 reports the number and frequencies of 'conceptual' episodes, episodes where students talk about other issues, and episodes where students talk about the task. Table 7 reports the kind of relations between episodes. It also reports the number of episodes focussing explicitly on a relation between concepts. These episodes are not included in analysis focussing on the relations between episodes, because they do not have a single conceptual focus.

	group 1	group 2	total	average
# episodes	**24**	**32**	**56**	
# episodes referring to one ethics concept	**15**	**15**	**30**	
frequency	***62.5***	***46.9***		***54.7***
# episodes not referring to ethics concepts	**4**	**9**	**13**	
frequency	***16.7***	***28.1***		***22.4***
# task focused episodes	**3**	**6**	**9**	
frequency	***12.5***	***18.7***		***21.8***
# episodes referring to more than one ethics concept	**3**	**2**	**5**	
frequency	***8.3***	***6.25***		***7.3***
undecided	**0**	**0**	**0**	
frequency	***0***	***0***		

Table 6. Number and frequency of episodes referring to concepts, the task or other.

types of relations	sub-types of relations	group 1 (total: 23)	group 2 (total: 31)	total	average
# pairs in 'conceptual' relation		**10**	**9**	**19**	
frequency		***43.5***	***29***		***36.3***
	in contrasting relation	**8**	**8**	**16**	
	frequency	***34.8***	***25.8***		***30.3***
	in supporting relation	**2**	**1**	**3**	
	frequency	***8.7***	***3.2***		***5.9***
# pairs in semantic or associative relations		**4**	**9**	**13**	
frequency		***17.4***	***29***		***23.2***
# pairs in other relations		**10**	**13**	**23**	
frequency		***43.4***	***41.9***		***42.6***

Table 7. Number of relations between the focus of one episode and the focus of the subsequent episode (pairs of episodes).

The results should be understood within an underlying 'logic' of relations between episodes. First, the total number of relations is one less than the total number of episodes. Second, the number of 'conceptual' relations cannot be deduced from the number of 'conceptual' episodes. This is because in principle each 'conceptual' episode could be followed by a 'non-conceptual' episode, though clearly, as mentioned above, a large amount of 'conceptual' episodes increases the likeness that such episodes are adjacent. A 'non-conceptual' episode entails that two relations (the one with the episode preceding it, and the one the episode succeeding it) are not conceptual. The same argument applies to episodes that contain a reference to two or more concepts. However, this doesn't mean that the number of 'other' relations can simply be obtained by multiplying the number of task-focused or undecided episodes by 2, since there would be only one 'other' relation if such episodes were adjacent. The relation between such episodes is either semantic or 'other'.

Figures 36 to 40 present examples for contrasting conceptual relations (figure 36, figure 37 and figure 39), supporting conceptual relations (figure 39), semantic relations (figure 38), and a task-focussed episode (figure 40). The 4th column reports the sequential number assigned to the episode, the fifth the principles the utterances of the episode refer to.

90	C	* and preserve life **	E9	Beneficence (preserving life)
91	E	isn't it just a general fact that doctors must work within the law?		
92	C	no, {I think?} that's a doctor's value		
93	E	Oh, yeah, yeah		
94	I	it is, yeah		
95		(2 writing)		
96	C	on the other hand, like {the? her?} husband {value?} {would be like?} you should let my wife, ... it's her life, so she has to decide whether she wants to die	E10	Autonomy
97	E	* value *		
98	I	his value would be ... prevent suffering, ... as you (pointing to E) were saying about		Beneficence (good and gentle death)
99	E	yeah		
100	I	what were you saying ...		
101	E	that the doctors in this case were more ..... aahm ... concerned with preserving her life than relieving her suffering...		

Figure 36. Exchange (of group 1) illustrating a contrasting conceptual relation between episodes. Episode 9 puts forward the argument that the doctors cannot assist in a patient's death because they are bound by the principle of beneficence, intended as the duty to preserve life at all costs. Episode 10 that focuses on the husband's value counters this argument by pointing out that the patient has a right to make her own decisions, and, further, that by preserving life at all costs, doctors would prolong the patient's suffering.

120	I	it's, ... it's my life, I ..... can't do it myself but yet suicide isn't ..... if I can do it myself it's not illegal, so therefore I should be able to, ... be able to, ... have someone assisting me, .. because I would do it anyway if I could		Autonomy
121	E	** I can't believe that there would be many people who disagree with it ..... unless they very strong religious beliefs [14:20] but, but, ... the decision on the end, I do bet that the people at the end didn't allow her to do it ... they didn't turn on their religious beliefs, but they turned on the fact that the whole British law would be changed.	E14	Universalisibility

Figure 37. Exchange (of group 1) illustrating a contrasting conceptual relation between episodes (the figure shows only the last contribution of episode 13). In episode 14, student I argues that the patient's right to decide for herself should be respected; student E points out that relying on that right would affect the legal system, implying that there may be difficulties in respecting such demands in principle (episode 14).

111	I	because, I know someone who is a doctor and they had {referred?}, *** had a huge motorcycle accident he actually{had to have?} blood transfusions, * but when it actually came out ** [that he was a Jehovah's witness] , ** how can a doctor try to preserve life ***		
112		(E and I continue to discuss)		
113	C	(to P) do you actually all agree that it was the right thing to do [in Mrs. B's case]	E20	
114	P	yeah, to a certain extend [4:42]		
115	C	ok, you're kind of impartial at the moment		
116	C	I basically agree that [in Mrs. B's case] it was the right thing to do because I don't want to be in this position		
117		(all together again)		
118	E	did you know that *** Jehovah's witnesses believe that the blood represents how good you have lived your life ...	E21	not relevant for cases

Figure 38. Exchange illustrating a semantic relationship between episodes (E19 and E20). In 111, student I is reminded of a situation of a patient who is a Jehovah's witness and hence refuses to have a blood transfusion. The situation presents a similar ethics dilemma than the euthanasia cases. Later, in 118. student E focuses on the doctrine of that patient.

145	C	ok, Diane Pretty * asking doctors to help her die	E26	Autonomy
146	P	yes, but if she says this one, I don't think there is anything particularly wrong with it. (cites from sheet) "I'm fully aware what the future holds and I've decided to refuse artificial ventilation", isn't that what the other {lady?} did?		
147	E	yes		
148	P	so why is it, ..., she's not asking for it now, is she?		
149	E	yes, but then later on it got really bad, and she said, I want it now.	E27	Beneficence (good and gentle death)
150	C	a doctor is gonna help her to die, and how is she's gonna {find?} this doctor, because I wouldn't ...	E28	Nonmaleficiance

Figure 39. Exchange illustrating a supporting and a contrasting conceptual relation between episodes. In episode 26, student C and P reiterate the patient's demand, and point out that this demand should be respected ("I don't think there is anything wrong with that"). In episode 27, student E points out that the patient's quality of life decreased rapidly, an utterance interpreted as referring to the principle of beneficence ('good and gentle death'). Both these principles support the patient's demand. Student C, in episode 28, however responds arguing that a doctor cannot help her because a doctor cannot harm a patient (principle of nonmaleficence).

132	P	should we read the other (turns sheet) as well?	E22	task

Figure 40. Example of a task-focussed episode

6.4.4 Discussion and conclusions

In this section, the results of the analysis will be discussed. In group 1, 62.5% of the episodes did refer to one principle, while 8.3% referred to more than one principle; in group 2, the frequencies are 46.9% and 6.25%, respectively. These data provide additional confirmation of the finding emerging from the process analysis, namely that the students have some knowledge about ethics principles, and more importantly, know about the contrasts between the principles. That is, the students appear to possess a system of lay ethics principles, and readily use it to interpret the cases. The low number of episodes focussing on issues other than directly related to ethics principles (group 1: 16.7%; group 2: 28.1%) confirms this conclusion.

With regard to the influence of the conceptual system on the introduction of new topics, the following observations can be made. Many pairs of 'conceptual' episodes refer to contrasting principles (group 1: 34.8%, group 2: 8.7%) rather than supporting principles (1: 25.8%, 2: 3.2%). That is, the discussion is characterised by pairs of episodes where first one student argues for (or against) the patients' demands, and subsequently another (or the same) student argues against (or for) them. For example, student C (see figure 36) argues against the patients' demand by pointing out that the doctors have a duty to preserve life (referring to the principle of beneficence, intended as 'doing good'), but then counters her own argument by pointing out that also ending the patient's suffering would mean doing good (principle of beneficence, intended as 'good and gentle death'). In these exchanges, the principle of universalisibility is often paired with the principle of autonomy. For example, in episode 15 (see figure 37), student I argues that the patient's demands should be respected, to be countered by student E who points out that in practice some patient's demands may be not justified, placing hence a limit on I's principled stance referring implicitly to the principle of universalisibility.

The general pattern emerging from the analysis is one of 'argument in support of the patient' - 'argument against the patient's demand', and the discussion can be characterised largely as an argumentation leading to the identification of the dilemma in the cases. This will be discussed further below.

Many of the pairs of 'conceptual' episodes stand in contrasting relations, but a few stand in a supporting relation (see table 7; for an example, see figure 39). These episode pairs refer to different ethics principles but support the same judgement (for the patient). For example, both the principle of autonomy and the principle of beneficence ('good and gentle death') would support the position that the patients' request should be respected and acted upon.

The low number of supporting relations between 'conceptual' episodes provides some additional evidence about the missed learning opportunity that will be described in section 6.6. In that section, it has been claimed that a fully integrated domain model seems not to have been acquired in the discussion. Specifically, the students fail to make supporting relations explicit, in contrast to the 'opposing' relations between ethics principles. It appears that the students have knowledge of the concepts pair wise (e.g. beneficence intended as 'good and gentle death' vs. nonmaleficiance, and autonomy vs. nonmaleficiance), but fail to see the *convergence* of the concepts, i.e. that some concepts provide converging support against a contrasting concept. This is taken as evidence that one of the most significant effects of learning with cases, namely a further integration of conceptual knowledge has not occurred.

From the high number of contrasting conceptual relations, and the low number of supporting ones, it can be concluded that the students are engaged in an argumentation, though the argumentation are not characterised by well-formed argumentation structures. Rather, patterns of argument – counter-argument are frequent as well as reference to specific facts ("she was suffering", "she wrote a letter before her ordeal") supporting one or the other argument.

The relatively high frequency of argument – counter-argument exchanges is surprising because all students of both groups do have a very clear and the same position on the cases: they side with the patients, most probably because of sympathy with their suffering but maybe also because the students value the principle of autonomy (non-paternalism) highly. The argumentations do hence not occur because students hold differing opinions, but because the students are aware that their position cannot be fully justified. In a sense, despite not believing personally in an argument, the students make it anyway (a devil's advocate position), leading to a well-balanced interpretation of the cases.

The low number of semantic and associative relations between episodes is a positive characteristic of the discussion. This finding confirms the overall impression that the students are interested in interpreting the cases according to ethics principles, that they do have a strong opinion about the cases and want to discuss it. The phenomenon of topic decay (Herring, 1999), characteristic for undirected, informal chats is virtually absent in the discussion. Rather, non-ethics issues discussed by the students are the law, the chain of responsibility of euthanasia cases, the role and 'power' of the GMC, i.e. issues that are relevant for these cases.

The number of 'other' relations appears to be quite high (group 1: 43.4%; group 2: 41.9%), and may be taken as meaning that the students' semantic and conceptual knowledge structure has only some effect on the introduction of new knowledge. However, as argued above, each episode not categorised as referring to a single ethics concept stands in potentially two 'other' relations to the preceding and subsequent episode. For example, if an episode focussing on the task (see figure 40 as an example) is preceded and followed by a 'conceptual' episode, both relations to these episodes would be categorised as 'other'. A similar counting would result if an episode between two 'conceptual' episodes refers to more than one concept.

The number of episodes semantically or associatively related is much higher in group 2 (29%) than in group 1 (17.4%). Indeed, the students in group 2 'veer off' into topics that are only somewhat pertinent to the cases (e.g. the legality of suicide). This group was composed of 5 students, rather than 3 as in group 1, a factor that may have contributed to the lesser focus on the cases themselves.

In discussing the results of the *effect* of the conceptual structure on the discussion, it is important to recall the alternatives to concept-driven contributions to the discussion. The first of these are simple associations that are characteristic for text contributions mediated by technologies supporting quasi-synchronous communication (Herring, 1999). In such environments, the focus on a topic may prompt the introduction of a topic that is superficially related to the previous one, such as, for example, when a contributor mentions her trip to Paris if the topic is the Eiffel tower. Discussions characterised by such topic drifts may be termed 'freely associative'. In educational situations, such free associations may occur, though it is clear that the task should provide direction to the discussion; if a facilitator is present, she may intervene when too much topic drift is evident.

The task hence is a second alternative influence on the contributions of the discussion. As described in detail in section 6.2, in the discussions presented here the tasks set by the tutor are rarely followed, and when they are followed, the discussion is unproductive. Specifically, it seems that the rationale for the applying the reasoning scheme is unclear to the students, and they consider it cumbersome; by interpreting the few utterances mentioning the reasoning scheme, it is evident that its application does not result in an output with which the students would be satisfied or which they consider useful or productive. The question then becomes whether there is an implicit task, i.e. whether, a posteriori it can be claimed that the students did follow a task set by them. Clearly this remains speculative, but it could be claimed that implicitly the students set themselves the task to 'provide an interpretation' of the cases. This assumption is supported by the evident clear position the students have on the discussed cases

and cases of euthanasia in general. Indeed, they disagree with the verdict reported, and hence may try to provide an interpretation that would support they position. When the character of the task is considered in this way, it is not anymore an alternative, but a support for the interpretation offered in this chapter. Indeed, by attempting an interpretation of the cases that supports their position, the students rely on conceptual knowledge, conforming thus to the major assumption of the analysis and interpretation.

A third influence on the contribution of the discussion is generalised dialogue structures, such as argumentation schemes. Though the literature on such structures is large, there is not yet any suggestion on the effect on knowledge retrieval these structures have. An interpretation of the discussions analysed here in terms of dialogues structures, and most likely, argumentation, is in parallel to the interpretation offered here. It is obvious, however, that this interpretation can specify with more clarity what is learned and which mechanisms operate in a collaborative learning situation. A general conclusion of this analysis is however that considering knowledge and the mechanisms of knowledge retrieval and acquisition is a productive approach to investigating collaborative learning with cases.

In sum, the results of the episode-focus analysis confirm the finding emerging from the process analysis: that the students have some lay understanding about ethics principles and especially that they know which principles stand in a contrasting relation with each other. This 'conceptual system' is highly influential in the discussion: the students attempt to justify their position on euthanasia cases, but are aware that they cannot be justified without violating other ethics principles. The discussions serve mostly to reinforce that conceptual system, as indeed it is adequate to conceptualise the cases.

6.5 The analysis of conceptual change

As described in section 3.3.5.3, conceptual change is a form of learning where a coherent, but faulty conceptual system undergoes a radical change. Conceptual change is evident in how people describe situations, and affects a few basic conceptions that provide explanations for a set of data.

In the discussions, conceptual change is not evident at all. The students do possess a skeletal conceptual system of ethics principles and also use these principles to conceptualise the cases. The conceptualisation based on that knowledge, i.e. the instantiation of the cases as ethical dilemmas, is considered to be successful, because indeed euthanasia cases represent current ethics dilemmas.

That the conceptualisation is deemed to be successful by the students offers one explanation why no conceptual change has occurred. However, to further explain the absence of conceptual change, it needs to be asked what would constitute conceptual change in ethics, and what misconceptions the students could possibly have that would require a reorganisation.

There is scant research on misconceptions in ethics. The most common form of misconception is about the role of ethics rather than about ethics principles themselves. For example, it has been found that a common misconception of students is that ethics is a discipline for solving problems and making decisions (Perkins, Geppert & Hazuda, 2000), rather than a set of principles founded on philosophical assumptions used to frame and reason about situations. This misconception is however not useful to speculate how conceptual change could have occurred in the discussions.

A possible misconception in ethics is the meaning of a 'good' action, a misconception that has its parallel in the two meanings of the principle of beneficience. The meaning of 'good' depends on whether an action's immediate effects or its long-terms consequences are taken into account: A narrow conception of the meaning of good would also change the interpretation of euthanasia cases: within a narrow conception, a physician's clinical intervention helping a suffering patient to die would not be seen as good. However, if her extreme suffering, her lack of therapeutic options and the suffering of her relatives are taken into account, that intervention may be seen as a 'good action'. The concept of beneficence has indeed these two meanings (see section 4.2.4.3, footnote 5), and their contrast constitutes one of the ethics dilemmas of euthanasia cases.

Clearly, though, the students' understanding of a good action embraces both meanings, and a conceptual change in this respect is neither necessary nor possible.

In order to show, however, that, even if not true conceptual change, but at least a modification of the conceptual structure has occurred, the discussion will be further interpreted with respect to the question whether the principles have been fully integrated, i.e. whether all possible relations between the principles have been understood. This is discussed in the next section.

To conclude the discussion on conceptual change and the lack of evidence in the discussion, it should be pointed out that it is impossible to know now whether the students had misconceptions about the principles, because no pre-session test on their ethics knowledge were carried out. For certain, no utterance is indicative for the fact that a student held a misconception and that the discussion helped her to identify and correct it (no experience of insight is apparent in any of the utterances). However, the next section will describe whether some modification of the conceptual system has occurred, i.e. whether conceptual learning other than the reinforcing of the existing conceptual structure and the acquisition of knowledge about the conditions of applicability of principles has occurred.

6.6 A missed learning opportunity: failing to complete the abstract representation

6.6.1 Introduction

In this section, an opportunity to learn missed by the students is described. Specifically, it will be claimed that the students did not see that in each of the cases (Mrs. B. and Mrs. Pretty) two principles provide *convergent* support for the patient's wish to die, and that both these principles contrast with a single principle. The failure to see the convergence of principles in these specific cases means that the cases' abstract representation is not complete. The claim rests on the fact that none of the utterances analysed mentioned that the two principles provide convergent support for the patient. Rather, the utterances either mention only one principle in support or against the patients' request for euthanasia, or mention the contrast between two opposing principles. The evidence of the failure to complete the construction of the abstract representation rests hence only on the absence of a clear expression of the convergence.

The failure is reported here because it provides additional insight into the character of learning, and contributes also speculations about learning outcomes. It is clearly also a phenomenon that should be addressed when proposing a learning design to improve learning. That is, this opportunity to learn should be promoted and supported by the learning design.

The following sections describe first the failure more in detail, and then discuss its significance.

6.6.2 Partial and complete abstract representations of the cases

To describe the missed learning opportunity, one of the basic phenomena of learning with cases is reiterated here: when people learn with cases, they use their existing conceptual knowledge to interpret the cases. They may use isolated concepts, but normally the use of one principle prompts the use of principles related to it.

The reference to a principle and the subsequent reference to a principle related to it (normally these principles stand in a relation of contrast), generates the pattern of arguments – counter-argument that are characteristic for the discussions (see section 6.4.4). So, for example, an argument for the patient's right to decide to end her life (i.e. using the principle of autonomy) may be countered by an argument pointing out that no one, and especially not physicians, should inflict harm (principle of non-maleficience) or that people's wishes cannot be granted in principle (principle of universalisibility).

The students conceptual system consists of a set of principles that are, in euthanasia cases as well as maybe in other ethics cases, in contrast (see figure 41)

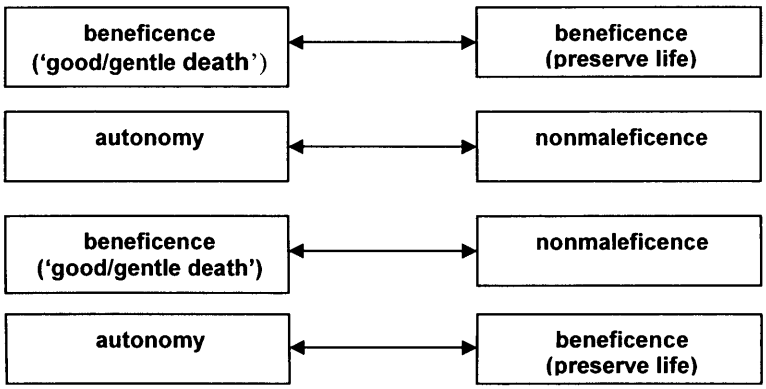

Figure 41. The diagram shows the likely organisation of the students' conceptual structure: it consists of a set of pairs of principles that are in opposition.

However, these small conceptual structures do not represent the cases completely, they represent only typical ethics dilemmas. Indeed, a complete representation would consist of a structure where two principles provide convergent support for the patient, against a single principle. In the case of Mrs. B., the principles of autonomy and beneficence ('good and gentle death') contrast with the principle of beneficence ('preserve life at all costs'), i.e. the two principles both support Mrs. B's demand (see figure 42). Similarly, the complete abstract representation of Mrs. Pretty's case consists of two principles (autonomy and beneficence, intended as 'good and gentle death') that provide convergent support for Mrs. Pretty's demand, against the principle of nonmaleficiance (see figure 43).

As described above, the failure to construct a complete representation is only on the basis of the failure to explicitly express the convergence of the principles. Whether the complete representation has been constructed nevertheless cannot be substantiated, because an assessment adequate for further verification (such as a post-session assessment) has not been made. However, it can be argued that the convergence would have been made explicit if it had been seen because the students are actively searching for support among principles in their knowledge to argue against the judges' decision. Though the patients' demand can be justified on the basis of one principle alone, an additional and indeed convergent support would reinforce the patient's case. In sum, it would be in the students' interest to explicitly mention the convergence.

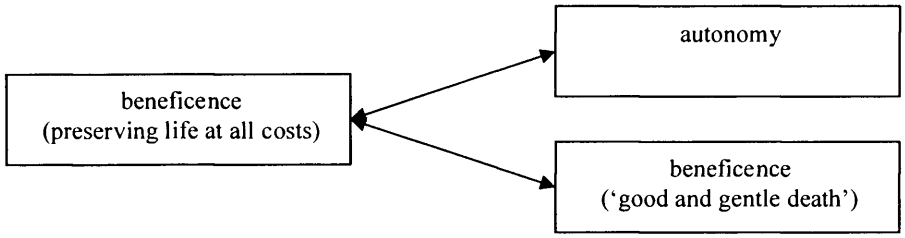

Figure 42. Complete schematic representation of Mrs. B's case

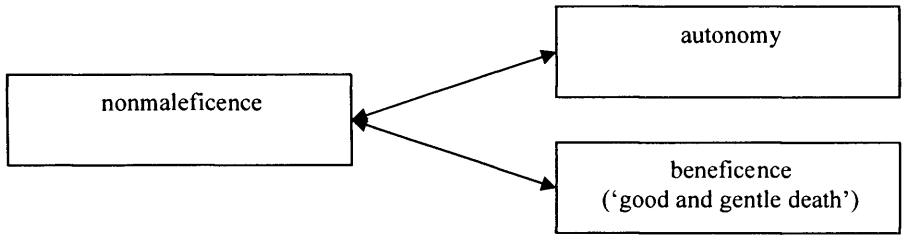

Figure 43. Complete schematic representation of Mrs. Pretty's case

6.6.3 Significance of the missed learning opportunity

The implications, in terms of learning, of the failure to construct a complete representation are multiple, though they remain, at this stage of the research, speculative. Most importantly, understanding that two principles provide convergent support against another principle may have prompted the students to reflect about the relationship between the converging principles. For example, the principles could be based on a single, more general principle or philosophy. Further, the understanding of the convergence may lead to more understanding about the principles themselves. So, for example, the two principles may be similar in aspects previously overlooked; e.g. they could have overlapping features. Clearly, this implication is speculative and would need to be illustrated with concrete examples (e.g. which would be the underlying philosophy, how similar are the two principles), a task that requires significant expertise in ethics. The understanding of the convergence may also lead to more understanding about the principles themselves. So, for example, the two principles may be similar in aspects previously overlooked; e.g. they could have overlapping features.

It should be pointed out that even the incomplete representations are valuable for learning: section 3.2.3.1 describes learning as the gradual structuring of the case which occurs through reusing earlier solved episodes (Gentner, 1989); subsequent exposition to structurally similar cases may lead to noticing the common structure that is available but has not yet been noticed because it was not required by the task demand (more on the mechanism of demand-driven re-

analysis in section 8.4.2.6[10]). That is, it is possible that the convergence is noticed in a subsequent problem solving situation with a structurally similar case. In this sense, also the incomplete representation is valuable.

The failure to generate a complete representation demonstrates the importance of the task in case-centred learning situations: as described in section, the students' (own) task is to find a justification for the patient's. Though, as described above, convergent support would provide an even stronger case for the patients, it is not strictly required. Thus, the students satisfy a minimum demand of their task. A different task demand, one that promotes a description of all principles involved in the cases and/or would require generating a graphical visualisation of the abstract representations, may have led to the noticing of the convergence and, as a result, to better learning.

6.7 Summary

This chapter has presented an analysis, and a descriptive and qualitative characterisation of the learning outcomes of small-group case-centred discussions. The results of the analysis allow the following characterisation of learning. Since much of the overall characterisation of learning relies on the process analysis discussed and summarised in section 6.3.5, and the results of the two additional analyses did not alter significantly the characterisation offered in that section, here only a short summary will be presented.

Overall, learning is conservative, but some valuable gains can be observed. The students strengthen their existing lay conceptual system on ethics and increase their knowledge about when and how to apply ethical concepts. In a sense, they operationalize their existing knowledge (cf. Anderson, 1982). The cases fulfil their role as promoting the integration of conceptual with real-world specific knowledge, i.e. the cases become concrete instances of the abstract relations between ethics principles (including the dilemma), and can be reused to discuss and reason about similar cases. Further, relationships with other cases play a significant role in learning: the students bring in cases from their personal experiences or public cases, and recognise commonalties and differences of euthanasia case. Identified common and distinctive features will function as features used to encode future euthanasia cases and also other cases representing ethics dilemmas.

Overall, the learning sessions were quite valuable, but would have been especially so if the students' conceptual system had been challenged more thoroughly. In a sense, the students have not acquired knowledge that is new for them, but rather reinforced what they already knew.

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[10] The mechanism of demand-driven re-analysis is a hypothetical mechanism conceptualised as a special form of analogical learning. It is derived from the analysis of a dialogue of students solving a software engineering problem by reusing a previously solved similar problem (section 8.4).

The absence of conceptual change and the failure to learn more about the meaning of ethics principles are to be considered major missed learning opportunities of the small-group discussion. These failures are addressed through a learning design, proposed in the next chapter.

Chapter 7

Design proposal

7.1 Introduction

The previous chapter has analysed and discussed the small-group discussions on euthanasia cases that are used in this thesis as examples of current practices. In this chapter, a proposal is presented that improves collaborative learning with cases in small groups. The proposed improvement addresses shortcomings of the 'learning design' of the observed current practices, but rests in its final conception on the framework (chapter 3) that stipulates how learning with cases is best designed to achieve major learning gains.

The chapter is distinguished into two sections. In the first section, the aspects of the learning design of the observed small-groups discussions are related to the qualitative characterisation of the learning outcomes. Section 2 then presents the proposal of the improved design.

7.2 Section 1: Summary of learning outcomes

7.2.1 Introduction

The aim of the present chapter is to identify which aspects of the original design have contributed to the learning outcomes, and which aspects were less than ideal in promoting learning. Three major aspects are analysed: the task, the cases, and the background material.

7.2.2 Design aspects conducive for learning

Overall learning method

The overall design of the discussions is sensible: the combination of lectures and case discussions is common in education, and it is adopted because conceptual knowledge acquired in a lecture is applied to real-world situations, leading to learning about how to use conceptual knowledge. In the PDS module, the design follows a more traditional format rather than a PBL format: students are first acquainted with conceptual and theoretical knowledge, and only afterwards apply that knowledge to concrete situations. It is in the small-group discussions, that the students are asked to apply their conceptual knowledge, and hence they are central to learning. Several learning theorists have indeed argued that students need to be given the opportunity to use conceptual knowledge, and that more learning gains occur in that stage rather than in a lecture; and there is certainly consensus that tutoring based exclusively on lectures is ineffective (Bransford, Brown & Cocking, 1999). Clearly, the question can be posed whether a PBL format would be more effective for learning. That is, it can be asked whether the students need a lecture at all, or whether it would be sufficient if they study and discuss the cases, and use textbooks if there is a need for more theoretical knowledge. There is, however, not yet a consensus on the effectiveness of the PBL format versus more traditional format (Norman & Schmidt, 2000; Albanese & Mitchell, 1993; Albanese, 2000). The conclusion can hence be made that the combination of lectures and case-centred small-group discussions in the PDS module is recognised as being educationally effective.

Multiple cases

One aspect of the design of the small-group discussions is particularly valuable: the use of two structurally similar cases. The importance of multiple cases for learning has been verified experimentally, and is especially justified by empirical models of expert knowledge acquisition and experiential learning. Much of the pertinent research literature has been presented in chapter 3. As a short summary, the exposition to multiple cases promotes the abstraction of differences and commonalties (Ross, 1984; Ross & Kennedy, 1990) that in turn promotes the abstraction of

a common deep structure and the acquisition of a domain-specific vocabulary (Gentner, 1989). Multiple cases require, however, to be matched carefully because people are able to abstract only a few features when mapping between the cases. The euthanasia cases conform well to this requirement: the marked difference between the two cases concerns passive versus active euthanasia, that in turn illustrated the difference between the concept of active intervention versus 'letting someone die (slip away)'. The difference warrants the application of different ethical concepts: active euthanasia conflicts with the principle of nonmaleficiance, while passive euthanasia with the principle of beneficence (intended as 'preserving life at all costs'). It can be argued, however, that the two situations are literally too similar, and that cases with more differences could have been equally well processed by the students, and led to more learning gains.

7.2.3 Deficient design aspects

The learning tasks and their relation to the learning goals

At the outset, the task "to identify facts and values" appears to be sensible and certainly is a direct 'translation' of the learning goal into a task. However, as described above, both groups barely carry out this task, and follow their own task. By doing so, the dialogue often focuses on substantive ethical knowledge rather than on the abstract categories of facts and values. To a degree, the students *go beyond* the original task to separate values and facts, and focus on *what* values and ethical principles are pertinent, and how they are related in the specific instances represented by the cases. By doing so, the students exercise practical reasoning: in their attempt to provide arguments to support the patients' request for assisted suicide, they identify ethical principles and values, and rely on them in their argumentation. That is, even though the original task is not followed, the students practice some practical reasoning.

The reasons for the students' divergence from the task can only be speculated about. The most likely reason is the lack of appropriate challenge that the original task presents for the students. The combination of a simple task with a material (the cases and the background knowledge) that are already in the public domain and hence very likely to be known to the students, may not present difficulties for the students.

With regard to the task, the first step, the identification of facts and values, is very easy to carry out. Students, at that stage of their education and personal development, should be well aware of the importance of values in decisions. The identification of specific values that underlie the players' opinions and decisions is more difficult, but, since the discussed cases are in the public domain and represent core ethical issues in the current cultural and social climate, it is likely

that the students have encountered value-focussed discussion, reports, comments, etc. about them.

The distinction between general facts and specific facts can be made by anyone with some level of schooling: general facts are biomedical knowledge (such as the lethality of the patient's disease), while specific facts are the symptoms and characteristics of that specific patient. The emphasis on this distinction may, as a consequence of it being quite straightforward, promote some puzzlement in the students.

The task is to be considered a 'deficient' aspect of the learning design because the time spent on understanding what the task is, and ultimately realising that it is quite trivial, could have been spent on another task. That is, the task reduces the effectiveness of the small-group discussions, and it can be claimed that a different task would have led to more learning gains.

The cases and the background material

Euthanasia cases present difficult challenges for the current culture and society, and they are considered unsolvable ethical dilemmas. Cases of this kind are used frequently in education because they can be discussed from different viewpoints, and hence provide good conditions for collaboration (the jigsaw method, cf. Shirouzu, Miyake & Matsukawa, 2002). Similar dilemmas are used to discuss issues in other domains, such as social or environmental policy (Pata & Sarapuu, 2003; Guzdial et al., 1997).

However, the background material given with the cases is not conductive for valuable learning, because it does not delve deeply into the meaning, theoretical basis or historical origins of those principles. The students largely know the principles introduced (autonomy, beneficence and nonmaleficiance) though they may not be familiar with the specific terminology. For example, the students know the principle of autonomy as 'the freedom to choose', and the principle of beneficence as 'the duty to do good'. In a sense, then, the lecture introduces the students to a more expert terminology of ethical principles, but not to a more expert *understanding* of them.

The lack of re-structuring and conceptual change can be partially attributed also to the cases chosen by the tutors. The cases themselves do not promote deep questions about ethics unless they are presented in combination with a more expert conceptual system. Indeed, one of the factors promoting conceptual change is the awareness that a conceptualisation is unable to explain or predict data (Chi & Roscoe, 2002). Having an expert 'solution' and explanation available, may prompt in the students a rethinking of the intuitive judgment.

The environment

The impact of the environment on the overall value of the discussion has not been investigated in this thesis, and is discussed here only from a most general point of view. An analysis of the impact of the environment on learning would, for example, ask whether learning tools (notebooks, textbooks) did support students in their learning task, and observe the affordances these tools present to the students.

At a most general level, factors that may have affected learning include the availability of the learning material and of background knowledge, and of resources to construct shared representations of interpretations or solutions. Also the synchronous face-to-face nature of the discussion has an impact on learning activities. However, a detailed investigation of these factors, are outside the scope of this thesis.

7.2.4 Summary

As has been argued above, the lack of challenge the original task poses diverts the students' attention to a task that they find more interesting. They argue on behalf of the patient and justify that argumentation with reference to ethical principles. This task has a major effect on what is learned: first, the students do practice reasoning and argumentation; and second, they acquire some more understanding of ethical principles and concepts. It could be said that the students' divergence from the original task resulted in learning about ethical conceptual knowledge conforming to the overall learning goals, but not to the specific learning goals of the discussions. However, also conceptual learning remains rather conservative: insights, conceptual change or a radical restructuring of their conceptual system are absent. Instead, students reiterate and reinforce their existing mundane conceptual system.

In the next sections, a learning design is proposed that addresses these shortcomings.

7.3 Section 2: Designing collaborative learning with cases

7.3.1 Introduction

The previous sections have identified those aspects of the original learning design that were conducive for learning as well as falling short of promoting more learning. These aspects, distinguished into task, cases and background material, are targeted by the new design. In the following sections, a learning design is proposed that addresses these shortcomings.

The design experiment implementing the new learning design will take place in a computer-based environment, presented in the final section. Investigating the effects of this new environment on communication and learning are outside the scope of this thesis.

7.3.2 Design proposal: targeting the material and task

7.3.2.1 Redesigning the material

Adding expert reasoning to the cases

A major problem with the original design of the small-group discussions was that the students were not given information about how experts reason about euthanasia cases. This has, among other factors, led to the near ubiquitous use of lay knowledge and to the generally conservative character of learning. The inclusion of expert reasoning (i.e. justification of expert opinion and verdict) may help address this shortcoming. Research relevant to this form of learning material is presented now.

A core distinction in teaching with examples is whether a solution is presented or not. A further variation, and the one advocated here, is to include expert justifications or explanations for solutions in the example presentation. Traditional problem-based learning does not present solutions, while cases do incorporate descriptions of outcomes of the application of problem solving strategies. In a sense, cases present the full picture of a set of events, while problems present only the initial problem state.

When presenting worked-out examples, problem solving or explanation tasks are normally given to the students. However, the distinction between the tasks often breaks down when students learn from worked-out examples: students may try to solve the problem even if given an explanation task, or spontaneously give explanations when looking at the expert solutions. This occurs because the expert solution may by unusable by the students. They become aware only of its value if they try to solve the problem on their own. It appears that when students identify gaps in their knowledge or are not satisfied with their own solution proposals, they are most amenable to adopt knowledge that closes these gaps. In a sense, then, the "worked-out example plus problem-solving/explanation task" paradigm reproduces a learning situation where people are aware of their limitations, but have, at the moment of the need for further knowledge, a source of knowledge available that helps overcome those limitations.

Worked-out examples make available a more expert model of domain knowledge, and describe how that domain knowledge is used to solve the example. This gives the students the

opportunity to compare their reasoning to reasoning of an expert, and provides a challenge to emulate that reasoning.

Including expert solutions and justifications of solutions with the case renders cases similar to worked-out examples. Some learning research has addressed the question how people learn from worked-out examples, under what conditions they are an effective learning material, and what are the reasons for their effectiveness.

There is consensus that novices profit most from using this form of learning material (Atkinson et al., 2000). Normally, novices rely on time-consuming and inefficient generic problem solving strategies, such as trial-and-error (Cooper & Sweller, 1987), because they lack knowledge about the structure of problems. Information about the structure of problems (e.g. how combinations of surface features represent a structural feature) is inherent in expert explanations (Chi, Feltovich & Glaser, 1981), and further show students how experts would initially encode and classify a problem. The opportunity to use that information decreases the reliance on generic problem-solving strategies (Zhu & Simon, 1987). Having available expert solutions, students acquire knowledge about the structure of problems. In a sense, an expert solution functions as a guide in student problem solving, whereby students adopt some of the experts' knowledge.

For example, expert explanations guide students' learning by structuring the problem. When faced with a new problem, students need to work out which aspect to the problem to place particular emphasis on or which to attempt to solve first. Information of this kind is memorised by students and can be used in future problem situations. Expert explanations reduce problem complexity and cognitive load, factors that have been linked to the improved learning gains with worked-out examples (Sweller & Cooper, 1985).

In general, a case is more amenable to high-level analysis than a problem. During an analysis of this kind, students use background knowledge to formulate a conceptualisation and interpretation, and learn about domain concepts rather than only about how to use these concepts. Further, having available solutions and solution procedures permits students to relate analytically problem statements with those solutions and procedures, whereby they acquire knowledge about the structure of problems. Learning with cases is likely to result in more 'scientific' knowledge on the particular domain, rather than only procedural skills (for this distinction in the domain of law, see Moskovitz, 1992).

Using more structurally similar cases

One feature of the original learning design has promoted substantial learning: the use of multiple structurally similar cases. Both euthanasia cases open similar questions about the ethics of euthanasia, but they also differ in the aspect of the form of clinical intervention demanded by the patient: active versus passive intervention. Mapping the two cases, a process that has occurred in the discussions, provides the students with valuable insight into classifying and reasoning about euthanasia cases.

In the design specification proposed here this feature of the original design is maintained, but extended: more structurally similar cases are given to the students to discuss. The main rationale for using more cases is to give students more opportunities for abstracting commonalties and differences. More cases permit however also other learning processes. Students can apply new knowledge acquired from mapping two cases to a third one. This gives students the opportunity to test out newly acquired abstract knowledge, and should lead to the refinement of a newly acquired schema or to learning a new schema.

7.3.2.2 Redesigning the task

As pointed out above, cases include explanations or justifications of why a specific solution has been adopted. For example, management cases describe also why a certain problem has been addressed in a certain way, and what the expectations of the players were. Often, the justification includes references to domain knowledge. The students have hence available information on how domain knowledge is applied to problems. This permits students to reconstruct not only how experts apply and use domain-specific concepts on a problem, but also the expert definition and meaning of a concept.

However, whether students learn from worked-out examples depends on how they use them, and some research has investigated this question. This research has found that explanation tasks are the most effective way to learn with worked-out examples. For example, students learn most when they spontaneously self-explain (Chi et. al, 1989; Pirolli & Recker, 1994). When students are prompted to explain, either to themselves or to others, learning gains increase also significantly (Chi & Bassok, 1989).

A common explanation of this effect is that the increased learning gains derive from a higher likelihood to identify gaps in one's own knowledge (VanLehn, Jones & Chi, 1992). An alternative or maybe complementary hypothesis points out those explanations are explicit verbalisations of knowledge, and may increase the likelihood that problem solutions are memorised together with justifications that would render the adaptation of the solution to a similar problem easier (Carbonell, 1986).

These findings from mostly controlled cognitive science studies have been used to devise instructional strategies. For example, Redmond & Phillips (1997) used a 'case plus explanation task' paradigm to teach students chemistry. The students were asked to explain the solution proposed by the expert. However, the study noted that students attempt to solve the problem on their own and made use of the expert explanation to solve it. The strategy was nevertheless successful because when attempting to solve the problem, the students could identify specific mistakes they made and correct them by looking at the expert solution and expert explanation.

A computer-based learning environment was developed by a collaborator of the project within which some research of this thesis was carried out. This environment provides basic tools for the display and navigation of the learning material (cases and background material), a chat for quasi-synchronous communication, and a shared whiteboard as a space to be used to generate jointly answers to the task. The environment will be presented in the next section.

7.3.3 The study environment

The computer system is used to carry out the studies described in chapter 8. It is an Internet-based peer-to-peer system implementing hypertext architecture (see figure 44 for a screenshot). The hypertext architecture permits the navigation through and display of the learning material (background material and the cases). The cases and the background material were saved as HTML files. The hypertext architecture consists of two parts: a window displaying the hyperlinks, and a window displaying the content of the HTML files containing the learning material. This display window can show only one file at a time. An HTML file would be displayed in that window by clicking on a hyperlink. The system implements also a basic chat facility allowing quasi-synchronous communication between the learners. The input to the chat occurs through the computer keyboard, and a chat message would be displayed in the chat history window by pressing the 'ENTER' key. These messages are displayed sequentially bottom-up (i.e. the earlier message would be displayed at the top of the chat history window). The chat history window can display 11 lines, each about 60 characters long (including spaces). If a message exceeds this length, it would continue in a new line (and the number of displayed messages would be reduced). Further, a shared whiteboard was implemented to be used by the students to produce joint answers. The whiteboard broadcasts each input as it occurs (synchronous communication). The whiteboard allows drawing basic graphical shapes (lines and rectangles).

As pointed out in the introduction, investigations on the effect of the environment on communication and learning outside the scope of this thesis.

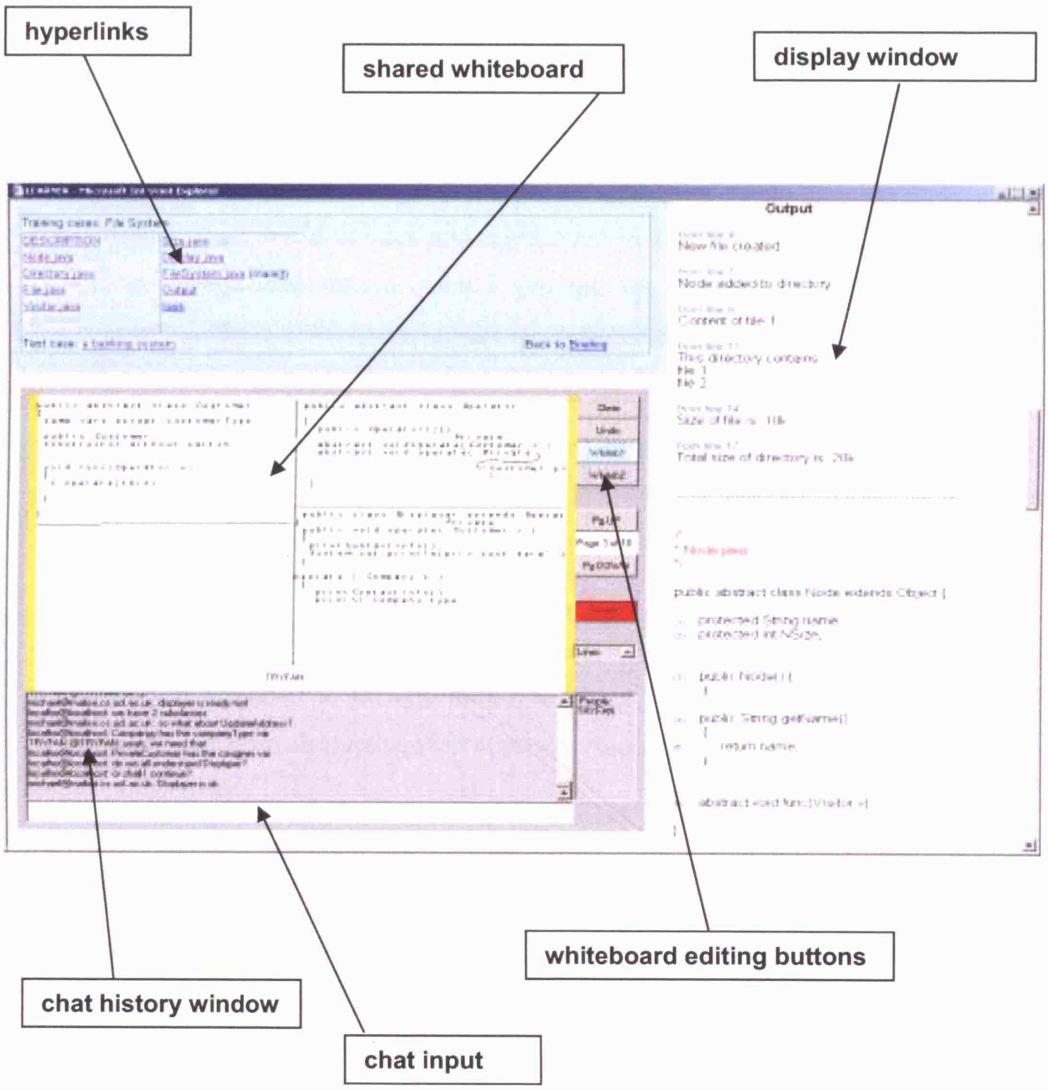

Figure 44. The screenshot of the Internet-based hypertext system used for the studies described in chapter 8. The screenshot illustrates the basic components of the system: a list of hyperlinks used to display the learning material in the display window, a chat input and chat history window, and the shared whiteboard.

7.3.4 Summary

The novel features of the learning design proposed here target especially two essential phenomena of learning: conceptual change and the adoption of a more expert conceptual system. The redesign is not only justified by similar learning designs and research into learning mechanisms, but also by the analysis of the f2f discussions: the students' divergence from the task set by the tutor does not only mean that the task does not provide an appropriate challenge to them, but also that their interest lies elsewhere.

The design of learning targets the following components:

- the challenge to produce a new and better conceptualisation should come from the inclusion of an expert opinion and explanation in the case description. The availability of an expert explanation should prompt the students to revise their initial conceptualisation of the cases, and lead to conceptual change.
- it is suggested to assign an explanation task. The combination of explanation task and expert explanation reproduces a situation where people fail to solve a problem, try to find an explanation for their failure but have expert knowledge available that helps them to identify gaps in their knowledge. Expert explanations also function as a model for the students to emulate
- one of the features found favourable of the original design, the use of multiple cases, should be extended to include more isomorphic cases, to encourage learning from mapping and from abstracting their common structure.

Chapter 8

Testing the learning design

8.1 Introduction

This chapter presents 2 studies carried out to test the learning design proposed in the previous chapter. The learning design aims to help students to construct more expert conceptualisations of cases by including expert opinions and explanations with the case description, and asking them to propose and justify a verdict.

The first (and main) study involves 4 groups of 3-4 students discussing 3 cases of medical negligence and liability, and the second study involves one group of 3 students solving software engineering problems. This smaller study is to be seen as a variation of the main study. Specifically, this study implements the cuing paradigm (Ross & Kennedy, 1990) to promote learning of a more expert interpretation by reusing earlier solved problems.

The chapter is organised as follows: in the first section the learning design is summarised. The next section describes the main (study participants and procedure), and gives an overview of the domain of learning. Then the three cases of medical law used in the study are presented. Each case is analysed with respect to the core question of negligence and liability, and a lay as well as

a more expert interpretation is described. The subsequent section describes the indicator used to identify conceptual change. The last section presents the smaller study, and discusses an extension of extant models of analogical learning deriving from observations on learning through the cuing paradigm.

8.2 Specifics of learning design

Chapter 7 specified the following components of the learning design: the content of the cases, the task and the learning environment. With regard to the case content, the design proposed to augment the case description with an expert opinion, expert reasoning and expert explanation. That is, beyond the report on events, actors, etc., learners should also have available information on why experts judge a case the way they do, and how they reason about the case. This additional information gives people the opportunity to learn about the domain from an expert. Several studies on learning with worked-out examples and solved problems have shown that people make good use of that additional information (cf. section 7.3.2.1): they tend to attempt to solve a problem on their own, and when they fail, they are particularly open to incorporate the expert knowledge into their own knowledge. In a sense, the design reproduces a situation where people becomes aware of their lack of knowledge, but have external knowledge available to solve a problem. Expert opinions and explanations added to the case description have two additional functions: first, they show how cases should be understood and thus function as a model for emulation; and second, they increases the likeliness that the learner is dissatisfied with her own interpretation if that differs significantly from the one of the expert, giving an additional impetus for learning. In this respect, the design is markedly different from the learning design of the small-group discussions on euthanasia cases (section 4.2.3.6) where the students did not have available a model of interpretation and reasoning for emulation.

The tasks assigned to the students ask students to "explain the verdict, by discussing how the judge arrived at his decision, given the information available" (see appendix 6).

The domain chosen for the main study is medical law, and in particular medical negligence and liability. This domain was chosen for two reasons: first, the participants of the study were drawn from the pool of students of the PDS module, and medical law was part of the module. The students who participated in the study described in this chapter had been given a lecture about it (see appendix 7). The participants had hence some background knowledge about the domain, though, as in the case of the discussions on medical ethics, this knowledge was conveyed only through a lecture. Similarly to the discussions on the euthanasia cases, the discussions therefore serve to apply theoretical knowledge. And second, it was hypothesised that the students' understanding of the domain of medical law would rely on lay interpretations of the meanings

of negligence and liability (e.g. being negligent means being sloppy, unprofessional, etc.), while these concepts have a clear legalistic meaning that often does not correspond to a lay meaning. It should be pointed out that the hypothesis on the students' lay understanding about the main concepts of medical law was not verified before the case discussions, nor has their understanding been investigated. However, the analysis showed that the hypothesis about a lay interpretation was correct, and the transcript examples presented in section 8.3.5 give some insight into a lay interpretation and lay meaning.

It is within the legalistic meaning that the students should interpret the cases. That is, more expert, legalistic interpretations of the cases are the learning goals of the discussions. The analysis aims to show whether those interpretations were indeed made, i.e. whether progress towards a more legalistic interpretation has occurred.

In sum, the domain of medical law, given the students' likely interpretation of the core concepts, permits hence a clear separation between two different conceptualisations and the eventual assessment of conceptual change.

It should be pointed out that it was not expected that the students would gain a full understanding of the domain. Rather, the expectations were limited to what is possible within an approximately 1 hour long learning session, with the background knowledge and understanding available to 1st year undergraduate students. The role of the relatively short sessions and the eventual learning accomplishment is to be understood within the dual nature of conceptual change (see section 3.3.5.3). While the structuring of a single case is to be considered a local generalisation occurring mainly on the external object, many more generalisations over a variety of cases would gradually improve the students' understanding of the domain.

The domain chosen for the second study presented in this chapter is software engineering. The interest of this study was to investigate collaborative learning by reusing an earlier solved problem. This mechanism is easier to investigate with proper solutions, as opposed to conceptualisations or interpretations. Further, structural similarity, intended as the applicability of similar solutions, is a necessary precondition for the study of the mechanism. Though the cases on medical law were chosen on the basis of structural similarity (they were all cases of 'omission of action'), the students failed to see that similarity. Indeed, as it became evident during the analysis, that structural similarity would have been of only relatively little usefulness, because the similarity is more a similarity of 'problem type' that does not assign a clear role and relevance to the individual case aspects. The cases chosen for this second study permit a clear distinction between the problem aspects and their role in the solution, and are hence well suited to study the sought mechanism.

8.3 The small-group discussions on cases of medical law

8.3.1 Subjects and study procedure

The participants for this study were students of the PDS module (see section 4.2.2) of the 1st year undergraduate medical curriculum at University College London. They were recruited through a mailing list and paid £10 for their participation. 11 students (7 female, 4 male) participated in the study. They were grouped into 4 groups (3 groups of 3 students, and 1 of 2 students), in dependency on their availability with regard to the time slots of the discussion sessions.

The study took place at the Computer Science Department at University College London. Each discussion on the cases lasted approximately 1 hour.

Three cases were given to the students for discussion in sequence. The PDS module for small-group discussions did not use these cases, and no small-group case-centred discussions accompanied the PDS lectures on medical law. That is, the students have not discussed cases of medical law before they came to the study sessions.

The cases were chosen from a web-based case repertoire that collects cases for education on medical law. The cases were the following: "Vadera vs. Shaw" (the Vadera case), "Chester vs. Afshar" (the Chester cases) and "Bolitho vs. Hackney" (the case of Patrick Bolitho). The cases will be discussed in depth below in section 8.3.3.

At the beginning of the session, the students were given 5 minutes to read through a short summary of the lecture on negligence and liability given to them a few weeks earlier as part of the PDS module (see appendix 7). Then the students were asked to click on a hyperlink to display a case, discuss it and provide answers sought by the task (see appendix 6 for the task context). The answers were to be written on the shared whiteboard (see figure 44). The students were told that they had 20 minutes to answer the question(s) for each case. Once the students were satisfied with their answers, they clicked to display the next case, discussed it and wrote the answers on the whiteboard. The cases were discussed in the sequence Vadera – Chester – Bolitho, except in group one where the second cases was the Bolitho case and the third the Chester case.

The students were also told not to speculate about facts but rather to attempt to explain and justify their answers with the facts reported in the case descriptions. For example, they were discouraged to justify their answers on the basis of probable event that could have occurred, but were not reported in the case description. They were also discouraged to justify their answers on the basis of what should have been done (e.g. "the GP is negligent because he should have taken

the blood pressure again"). The students were told that such speculations are uncommon in judicial practice and that indeed the courts reached decisions based on the described facts only.

A facilitator was presents during the discussions. His task was only to organise the discussions (e.g. to remind the students of the time limit), or eventually to remind the students of their tasks.

8.3.2 The concepts of negligence and liability

This section gives a short introduction to the legal concepts of medical negligence and liability. These two concepts are the most pertinent ones for the cases discussed in the study session. The following description summarises the lecture on medical negligence and liability given to the students within the PDS module, but clarifies also the concepts for the purpose of capturing their different (lay and expert) meanings. The clarification was complied on the basis of published accounts on the disputes centring on the cases, including discussions in the British House of Lords.

8.3.2.1 Negligence and liability: an introduction

Negligence and liability are similar in that they generally both apply to behaviour that has resulted in harm being done to a party. The applicability of liability, however, requires that an undisputable case be made for an activity having had a causal role in the harm. For example, in the case the lack of maintenance of a public path has resulted in an injury of a party using the path, a case of negligence can be made in principle, while liability can only be applied if the occurrence of the harm was reasonably foreseeable and the relationship between the lack of maintenance and the harm caused by it is sufficiently proximate. Liability is thus a much more difficult judgement make because while a test of standard of care can be applied to verify negligence, real causes of harm can be multiple including the own behaviour of the injured. Since the proof for liability is so difficult and could not be reached in cases where intuitively a case of liability could be made, the proof has been extended to include cumulative causation, i.e. where an activity co-contributed with other factors to harm or raised the probability of that harm to occur.

Proofs of medical negligence and liability make often reference to a reasonable standard of care that is expected from someone providing a certain service. That is, a breach of duty of care is determined with reference to common practices rather than objective measures. In several cases, including in one of the cases discussed by the students (Bolitho vs. Hackney), the ultimate arbiters of negligence were a group of experts who operated in similar circumstances as the situation where the harm occurred. The recourse to experts to determine a standard of duty of care is called the Bolam test. The Bolam test determines whether a defendant has acted in a way that a body of expert would have acted. The Vadera case was the first one in recent history were

negligence was determined not by the Bolam test but by the judges' application of scientific logic. The judges' reasoning differed from the medical experts' in that they deemed the standard of care applied to the case of Mrs. Vadera as being substandard if a more general scientific logic is applied.

8.3.2.2 Two meanings of negligence and liability

As will be described more in detail in the section on learning below, the definitions of the notions of negligence and liability offered above provide not more than an initial guideline for the application of the concepts. These descriptions are, however, those presented to the students in the lecture, and it is clear that they offer only a small help for discussing the cases, and, in particular understanding these complex notions. The knowledge so conveyed in a lecture, constitutes, together with lay interpretations or associations of the terms 'negligence' and 'liability' the knowledge available initially to the students. The function of the discussion is to facilitate the approximation of the students' understanding towards the expert meaning of these concepts.

For this study, a distinction is hence made between the lay meaning of the concepts and the expert meaning (here called the 'legalistic' meaning). This distinction is made in order to capture the correct interpretation of the case that contrasts with the one that relies on the lay meaning of the concepts. The difference between the two meanings is apparent in the way the students interpret the aspects, justify their verdicts or opinions and especially in what questions they pose on the cases. The verdict of each of the cases depends critically on answers to specific questions, and it is the judge that poses and attempts to these. These questions are adaptations of the concepts of negligence and liability to the specific case discussed.

In cognitive terms, the questions result from the correct structuring of the case[11], i.e. the question assigns a role and relevance to the concrete case aspects that are interpreted according to the questions. For example, that fact that the records of visits of Mrs. Vadera were lost prompted several students to judge the doctor as negligent. However, from a legal perspective, this fact means that the court cannot know about the state of health of Mrs. Vadera, and hence no case for negligence can be made (for the details on this case, see next section). The correct

[11] Since structuring is a holistic process, it is more accurate to say that the question results from and entail the structuring of the case. In any case, the structure and the core question on a case are mutually dependent.

structuring of the case is hence reflected in two indicators: whether the correct question is posed, and whether the facts have been given a correct interpretation.

The 'assessment' of learning, i.e. the judgment whether the students were indeed able to construct an interpretation of the cases that is similar to how an expert would interpret them, is hence critically dependent on whether they pose the right questions. There are certainly overlaps in meaning between the lay and the expert understanding of the concepts. However, when applied to the case, the distinction becomes clear, and the analysis can identify whether an expert or mundane meaning underlies a judgement, justification or question. In a sense, then, for the purpose of this study the lay – expert distinction reflect the incorrect – correct distinction. The distinction will become clearer in the following discussions on the cases.

The core question and the legalistic interpretation of the case aspects are the learning goals, i.e. learning will be said to have occurred if the students pose the right question and interpret the aspects correctly.

The next sections describe now the cases and their learning goals. Each of the cases is described detail with particular attention given to the core question – the one the students should identify – that each case posed.

8.3.3 The cases

8.3.3.1 The Vadera case

The Vadera case is about a young woman who, after having taken the contraceptive pill despite a one-time hypertensive reading at her GP (general practitioner), developed stroke-like symptoms and then suffered a near-fatal stroke that left her partly paralysed. The judgment on negligence and liability centres on the question whether the GP has, by prescribing the contraceptive pill, caused or causally contributed to Mrs. Vadera's stroke (see appendix 8).

Vadera – the core problem

Despite the complex legal discussions and judgments the Vadera case has inspired, there is now consensus that Mrs. Vadera's GP was negligent in not ascertaining whether the hypertension evident in the first (and only available) reading was 'sustained' or indeed a temporary white-coat hypertension (WCHT, a temporary hypertension caused by the physician's presence). It is also widely accepted that the intake of the contraceptive has contributed to the stroke, hence, that the GP was liable. Both these judgments require additional justifications (such as the issue of cumulative causation), that however are not described in the lecture and would pose a too

great a challenge for first-year medical students (although some students identify them, see below).

Specifically, while the application of the Bolam test determined that the lack of verification whether Mrs. Vadera's hypertension was sustained or not was indeed common practice and the diagnosis of WCHT would have been made by a body of experts, the judges at higher instances ruled that the absence of the *exclusion* of sustained hypertension (that could have been verified by subsequent readings) violated a common scientific principle.

The Vadera case brought into focus several other difficulties with cases of medical negligence and liability[12]. One further issue discussed in expert journals was the requirement that Mrs. Vadera provide proof – the case being in a civil court, where the burden of proof is on the plaintiff, instead of being on the defendant as in criminal cases – that her hypertension was indeed sustained rather than temporary. The subsequent stoke could not be taken as adequate proof for this since it could have been caused by other factors including obviously the contraceptive pill. While from a mundane perspective either of these factors (i.e. the failure to test for sustained hypertension and the prescription of the pill) point unequivocally towards a guilty verdict, the impossibility to disentangle the factors and identify a clear causing factor entails that such a verdict cannot be made. Indeed, in the first two instances the defendant has been found neither negligent nor liable. The stringent application of legal reasoning and practice would, hence, counter an intuitive judgment.

The learning goal

According to the first two instances hearing the case, if a case for negligence is to be made, the main question to be answered in court is the following: "has the GP acted negligently in prescribing the contraceptive pill to a hypertensive patient?" This question requires the answer to the question whether the patient suffered indeed from *sustained* hypertension. Since this question cannot be answered, due partially to the lack of documentation, no case for negligence can be made. Indeed, the high BP reading made immediately before the prescription of the pill is not an indication for sustained hypertension. The GP acted irresponsible and unprofessional in not following up this single BP, but it cannot be said that the GP administered the drug to a hypertensive patient. The GP's diagnosis of WCHT is in line with standard practice, since indeed it is not usual that a patient of 22 years of age would suffer from hypertension. By not *excluding* the hypothesis that Mrs. Vadera's high BP reading was indeed not a case of WCHT, the GP has merely acted unprofessionally.

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[12] The following discussion summarizes a thorough argumentation on the Vadera case's complexity offered in Goldberg (2000).

Several discussions have argued against this conclusion. The most forceful argued that, while it is true that it cannot be said that the GP has administered the drug to a hypertensive patient, the lack of tests that would exclude sustained hypertension amounts to more than just unprofessional conduct, but does indeed constitute negligence. The problem with this argument is that the unprofessional behaviour does not sufficiently proximate to the harm, i.e. the stroke.

8.3.3.2 The Chester case

The Chester case is about the question whether the lack of adequate warning about the risks of a surgery can be considered negligent, and the surgeon may be partially liable for the harm caused. Mrs. Chester claimed that she had not been adequately warned about the risks of a back operation that left her with sensory and motor impairment, and that hence the surgeon was partially responsible for her harm. She claimed that had she known more about the risk, she would not have consented to the surgery (see appendix 9)

Chester – the core problem

The Chester case raises several general ethical questions – related to an individual's autonomy and freedom of choice – but can be interpreted as questioning the legalistic meaning of liability: though the doctor's failure to warn the patient about a possible even if tiny risk involved in an operation has not directly caused the injury, the doctor has some responsibility in this injury happening. Specifically, it can be argued that, as with simpler cases of liability, the lack of a full warning has increased the risk to the patient, since with a full warning she may not have undergone the operation.

A legalistic view of liability posits a strict causal connection between a clinical intervention and harm at the centre of a judgement. Judgement in the Chester case is complicated by, first, it being a case of omission of act, and second, by this (omitted) act being an adequate warning rather than a clinical intervention. The plaintiff, Mrs. Chester, had to prove that if she had been given a more substantial and more precise warning she would have never consented to the surgery, not by another doctor nor in the future. In other words, she needs to prove that the lack of adequate warning has led to the harm or increased the risk of being harmed. However, even if she would have deferred the surgery – but ultimately consented to it – after further consultations with other surgeons the causal connection would have been severed, since any operation would have carried with it the same risk. This causal connection is virtually impossible to prove.

A further fact rendered a judgment even more difficult: the surgeon was informed about the patient's aversion to surgery, and may have hence limited his warning to the patient in order to ease her decision, because he thought that surgery was the best option to free her from her pain.

The surgeon's low-key warning resulted hence from consideration of his patient rather than negligence, intended here as sloppiness. The surgery, would it have succeeded completely, could even have had the effect of reducing the risk to the patient, which may have increased had she deferred surgery for a substantial amount of time. In a sense, the absence of adequate warning was intended as a reduction of the risk.

The learning goal

As pointed out in the section on the main problem of the case, judgment of the case depends on the interpretation of liability: a strict scientific view of causality would dismiss Mrs. Chester's appeal. A different view that would judge the surgeon's 'responsibility', would accept it, though this view would be difficult to justify. Indeed, it is certain that the surgeon has not 'acted in bad faith', as he would have done if he simply forgot to warn the patient adequately. Hence, it can be argued that the surgeon acted responsibly by withholding information because by doing so he increased the chances that the patient would consent to surgery that was, in his view, the best option for his patient. From these considerations derives the paradox that a surgeon acting responsibly and in good faith has harmed his patient. Judging such a person as acting negligently is a complicated task, since the episode certainly does not 'put a question-mark over' his character and his general approach to being a doctor. This case embodies quite clearly the differences between a lay and an expert view of negligence.

8.3.3.3 The Bolitho case

Patrick Bolitho, a 2-year old child with breathing difficulties, died after the doctor on duty failed to attend twice to help him. While the hospital admitted negligence, it claimed that the doctor was not liable because even if she had attended, she would not have performed the procedure that could have saved his life. The solution to the Bolitho case rests entirely on the correct application of the Bolam test (see appendix 10).

Bolitho – the core problem

The core problem of the Bolitho case derives from the defendant's claim that she would not have intubated the child, even if, contrary to the facts, she had attended the child. It is this claim that needs to be accepted by judge and, if accepted, leads to the question of causation, and hence liability. As noted in the description, the hospital admitted immediately to negligence for not attending the child, and hence the basis for the question of liability is given. This question is discussed now in detail.

If the defendant had claimed that she would have intubated the child if she had attended to it, she would admit to liability, because with it she admits that the failure of performing a clinical

intervention would have resulted in a different outcome, most likely in the child not suffering from the lethal heart attack. However, her opposite claim renders the role of her non-attendance in a different light: if she wouldn't have intubated anyway, the outcome would have been the same, whether she had attended or not. Hence, the absence of the clinical intervention cannot be held directly responsible for the harm, and a judgment of liability would fail. The negligence judgment would, however, be upheld purely on ground of common practice: a doctor is required to attend a patient in distress.

In sum, the core problem posed to the students derives from the doctors' statement on her intervention, and what this statement leads to if found acceptable by the judge: the Bolam test is only to be used as a result of the statement.

The learning goal

The students should understand that the concept of liability requires normally the satisfaction of the notion of causality, and that this notion is difficult to satisfy even if the criterion of proximate causality is included. The doctor claimed that she would have not intubated (for various reasons, including the complications that may arise from intubation) and that hence the harm would have occurred anyway. The failure to attend is, through this claim, divorced from the harm, and this renders it difficult for the plaintiff to prove that the continuing exercise of proper care would have had the opposite outcome (i.e. the harm would have not occurred). An eventual verdict depends on what constitutes 'proper care'. The doctor cannot, however, be judged as being liable strictly on her lack of action.

8.3.4 The analysis scheme

8.3.4.1 Introduction

The aim of the analysis is to capture the students' conceptualisations of the cases, and especially to evidence whether the students were able to conceptualise the cases correctly. As has been described in section 8.3.2.2, the concepts of negligence and liability can be understood in a lay way ('sloppy', 'naïve'; 'to blame', 'at fault'), but experts have a different understanding of them. This distinction is described as the lay versus the legalistic meaning of the concepts. The different meanings of the concepts lead to a different conceptualisation of the case, to a different justification of a verdict and at times even to a different verdict.

The main aim of the analysis is to identify the core question that the court must answer in order to deliver a verdict. This core question depends on how the case is conceptualised.

By capturing conceptualisations of a case, changes in conceptualisations can in principle become evident, and the question on whether the students are able to at least approximate the expert meaning of the concepts can be answered. This section presents the theoretical foundations of the analysis that justify the analysis approach to evidence conceptualisations from utterances.

Parts of the foundations have already been presented in sections describing research that investigated how the description of problem situations is dependent on the conceptual structure of the problem solver (section 3.2.4.2 and 3.3.5.3). Further, the derivation of an analysis approach and broad analysis scheme from that research has been described in the section on capturing conceptual change (5.4). In this section, the foundations and the specific analysis scheme derived from them and adapted to the studied learning situation are described.

8.3.4.2 Indicator of learning: justifications and questions

The conceptualisation and derived assessment of learning in this study is to be understood within the notion that conceptual change is external, though a common assumption relates it to an internal restructuring (see section 3.3.5.3). In the study only the external restructuring is assessed, the gradual acquisition of a better understanding assumed to be the consequence of several similar learning sessions.

The research review in sections 3.3.5.3 and 5.4 provides the basis for the assumption of the analysis in this chapter: that the descriptions of the cases reveal how the students are, at a specific moment in the discussion, conceptualising the cases. The analysis attempts to identify whether the students have posed the core question (to be answered in court). This analysis targets the students' justifications of verdicts, the students' statements and the students' questions.

In a court of law, the judgment of a physicians' behaviour in terms of negligence and liability is based on one ore more specific questions the court needs to answer. The cases' facts (e.g. the patient's symptoms, the physician's actions or omission of actions, the patient's medical history) are the basis upon which this question is posed. For example, the core question of the Vadera case is: "has the GP prescribed the contraceptive pill to a patient suffering from sustained hypertension?" These core questions rely on a legalistic understanding of the concepts of negligence and liability. Ideally, during the discussions the students would come to identify these questions as the questions that need to be answered, pose them and attempt to answer them.

However, posing these questions explicitly and clearly occurred quite rarely during the discussion (as an example of how students poses core questions see figure 46 and figure 47), though clearly, these messages provided the most valuable data on conceptual change. Much more frequent were justifications of verdicts. That is, the discussions are characterised by argumentations on the courts' verdicts or the students' own opinions and verdicts, in line with the task set to the students. Justifications of verdicts allow a valuable insight into the students' conceptualisations of the entire case, and are hence most frequently used for the analysis.

The value of analysing justifications will be demonstrated here by the following example that is paradigmatic for several messages.

13	**Erin 14:25:52**	**Yes I tend to agree with the verdict the doctor is clearly negligent as he should have taken the womans blood pressure more than once and not just assumed it was due to nerves. However the doctor is not legally liable as the high blood pressure could have caused the stroke irrelevant of the pill.**

Figure 45. A chat message expressing and justifying verdicts on Dr. Shaw (the Vadera case) [13].

The utterance reveals the following erroneous reasoning: first, the failure to take the blood pressure again does not constitute by itself negligence unless a clear relation to the harm is made. Second, the student mentions two justifications in support of each other and without explaining how they support each other. The GP could be negligent in not excluding sustained hypertension, and the GP can also be negligent in making an incorrect diagnosis. Hence, the two justifications do not necessarily support each other, and discussing them separately could have led to a better understanding of the relevant concepts.

Third, if it is assumed that the high BP is the cause of the stroke (thus excluding the pill as the cause of the stroke), it means implicitly that the student is satisfied that the high BP was indeed sustained; and hence, that the GP was negligent in prescribing the pill to a hypertensive patient. Therefore, the student appears to be satisfied that Mrs. Vadera suffered from sustained hypertension, and fails to identify this question as the core question of the case. These verdicts and their justifications reveal the incorrect conceptualisation of the case and a lay interpretation of the concepts of negligence and liability: the core problem of the case is indeed not whether the GP has failed to make subsequent blood pressure readings.

The example shows also that sometimes the students base their justification on the mere fact of an omitted clinical action, rather than on attempting to relate causally that omission to the harm. The phrase "...should have done..." is evidence of the students' lay interpretation of the cases.

[13] The students' chat messages are reproduced in their original form, that is, grammatical or orthographic errors were not corrected.

Justifications are also valuable indicators of the correct conceptualisation of the whole case. For example, a student discussing the Chester cases justifies a not-negligent verdict by saying that "even if she had known more about the risks involved in the surgery, she would have consented to it nevertheless". This message reveals that the student has identified the causal relation between the knowledge about the risk and the patient's decision as the relation upon which a judgement is based. It is a small step from the identification of the relation to the core question: "would the patient have consented to surgery, even if she had known more about the risks?"

8.3.5 The analysis

8.3.5.1 Introduction

The aim of this analysis is to identify whether the students were able to conceptualise a case within a legalistic meaning of negligence and liability. This analysis targets chat messages where the conceptualisation of the case as a whole is evident, in contrasts to the aspect analysis (described later) that targets individual aspects. To reiterate, the analysis looks for chat messages where the core problem of the case is mentioned, or from which the conceptualisation of the case as a whole can be inferred. Justifications of verdicts are a valuable source to infer an underlying analysis, but also statements and questions may be used.

Particularly important is that a chat message expresses the conceptualisation of the case as whole, rather than only parts of it. For example, when discussing the Vadera case, the students may judge the GP's omission of action as negligent without however considering how that omission is related causally to the harm. The structuring of the cases within a single conceptualisation is essential for understanding them, and indeed all the cases were solved, in a court of law, by answering a single core question.

Some keywords, key phrases or telltale signs are helpful to identify an chat message expressing the conceptualisation of the case as a whole. For example, the keywords "crux", "core", or the key phrases "the problem here is..." and "the main question is..." render the identification of interesting chat messages easier. However, such signs are relatively rare, and often an inference must be made on the basis of a statement.

To identity changes in the conceptualisations, a discussion of a specific group on a specific single case were divided into three phases: 'beginning', 'middle' and 'end', in correspondence to the first, second and third third of the discussion. This division permits to capture whether a correct conceptualisation has resulted from the discussion and the students' engagement with the cases, or whether they knew from the beginning how to conceptualise it correctly.

Figures 46 to 50 represent some chat messages included or not included in the analysis. The figures represent the line number (first column), the contributor and time stamp (second column) and the message.

Chat messages from which a conceptualisation was inferred

50	**David 14:27:42**	**I think that the crux here is whehter the second meeting took place**

Figure 46. A problem statement with the keyword 'crux'. The conceptualisation is incorrect.

153	**David 14:56:20**	**isnt this about duty of care, and the fact that the registrar was in a breach of duty by not attendign, regardles of what they would have done**

Figure 47. A question on the case as a whole, with the key phrase 'this is about'. Also this conceptualisation is incorrect.

90	**Susan 14:46:31**	**so had she known of the risks, she would have continued to suffer from chronic back pain**

Figure 48. A statement from which the conceptualisation of the case can be inferred. The conceptualisation is correct.

Chat messages from which a conceptualisation could not be inferred

25	**Claire 14:27:52**	**because he thought it was just nerves causing the high BP**

Figure 49. An explanation establishing a causal relation between two aspects of the Vadera case. The explanation is only on two aspects, and the conceptualisation of the case cannot be inferred.

13	**Erin 14:25:52**	**Yes I tend to agree with the verdict the doctor is clearly negligent as he should have taken the womans blood pressure more than once and not just assumed it was due to nerves. However the doctor is not legally liable as the high blood pressure could have caused the stroke irrelevant of the pill.**

Figure 50. A message attempting to conceptualise the case as a whole. Though all relevant aspects are mentioned, the underlying conceptualisation does not relate the concepts of negligence and liability. This message already reported in figure 45.

8.3.5.2 Results, by group and by case

Table 8 summarises the results of the analysis. It shows, for each group and for each case, whether the case was conceptualised correctly, and in what phase the correct conceptualisation was evident.

Case/group	Group 1	Group 2	Group 3	Group 4
Vadera	-	-	-	begin
Chester	begin	end	begin	-
Bolitho	end	middle	begin	-

Table 8. Summary of the results of the analysis. The table shows if a group was successful in conceptualising a case correctly, and in which phase the conceptualisation was mentioned.

The results can be summarised as follows: in 3 out of 12 discussions (4 discussions on 3 cases each) the case was conceptualised correctly towards the end or in the middle of the discussion, while in 4 discussions the case had been conceptualised correctly at the beginning. In 5 discussions, the students did not conceptualise the case correctly. This means that only three discussions lead to learning intended as a re-conceptualisation of the case.

With respect to the question whether including expert opinions and explanations with the case description helps students to overcome lay understandings, no strong conclusions can hence be drawn from the results. That is, it cannot be concluded whether the design promotes and supports the form of learning is seeks to promote because the results show successes as well as failures. The fact that in 4 discussions the cases were conceptualised correctly at the beginning of the discussion removes them from contributing to evaluating the efficacy of the learning design.

Figures 51 to 54 present examples of messages for each group showing a correct conceptualisation of the cases. The figures present the line range (second column), i.e. the number of the first and last message on a particular case, and the message examples as nested tables. For each message, the line number (first column in nested table), and the contributor and the time stamp (second column) is reported.

Group 1

case	line range	message
Vadera		No progress evident
Chester	109 - 143	116 Stephanie 15:11:20 but hard to know if even with advise she would have done it or not 117 Stephanie 15:11:27 which is the pbl here
Bolitho	74 - 106	97 Kate 15:04:31 in previous cases of kids with resp distress what is standard practice and usual outcome 104 Kate 15:06:45 yes, he should look at case wrt similar cases and the m.o.- if intubation is usually a last resort then the dr cant be blamed

Figure 51. Examples of chat messages of group 1 evidencing correct conceptualisations. Messages 116 and 117 are correct in stating that the problem of the Chester case is whether the patient would have refused the surgery if more advice had given. Messages 97 and 106 identify the problem correctly as being solvable through the Bolam test.

Group 2

case	line range	message
Vadera		No progress evident
Chester	67 - 121	90 Susan 14:46:31 so had she known of the risks, she would have continued to suffer from chronic back pain 98 Susan 14:48:39 do you really think that she would have refused the operation even if she had known the risks?
Bolitho	130 - 174	145 Erin 15:04:47 It comes down to what a peer of doctors think is the right thing to do in the situation

Figure 52. Examples of chat messages of group 2 evidencing correct conceptualisations. Message 90 is an inference on the patient's potential reasoning relying on the core question of the Chester case. Message 145 identifies the problem correctly as being solvable through the Bolam test.

Group 3

case	line range	message		
Vadera	16 - 77	No progress evident		
Chester	87 - 137	90	David 14:39:56	so surely the judge here is asssuming the doctor warned her adequetly, or that she would have made the same decsion regardless
		101	David 14:41:12	she cant claim she would have refused surgery to trry and alleviate it
		102	David 14:41:30	but if she had been warned, shed prolly have risked it neways
		121	Hywel 14:44:39	so, the verdict is basically based on the fact that the judge did not believe that she would have changed her mind had she been given alternative advice
Bolitho	152 - 193	152	Hywel 14:56:16	maybe you would have to ask whether another registrar would have intubated the child had he/she seen him
		153	David 14:56:20	isnt this about duty of care, and the fact that the registrar was in a breach of duty by not attendign, regardles of what they would have done

Figure 53. Examples of chat messages of group 3 evidencing correct conceptualisations. All 4 messages on the Chester case identify correctly the core question of the case. All messages on the Bolitho case are correct and made at the beginning of the discussion.

Group 4

case	line range	message		
Vadera	7 – 63	14	Jason 16:06:41	yea there is nothing to say that her being on the pill caused her any additional harm so the doctor was not at fault by giving them to her
Chester		No progress evident		
Bolitho		No progress evident		

Figure 54. The chat message of group 3 evidencing the correct conceptualisation of the Vadera case.

8.3.5.3 Discussion

The two factors that appear to be mostly responsible for success or failure are the cases and the groups themselves. The influence of the second factor will not be discussed, only to say that 3 groups show a quite consistent performance (they 'solve' 2 out of 3 cases), while one group performs particularly poor. The pattern of performance of the three groups (they all failed to understand the Vadera cases) gives some insight into the causes for success and failure.

The Vadera case represents a difficult challenge to the students, while, contrary to expectations, the Chester case appears to be the easiest (two groups understood its main question at the beginning of a discussion). The Bolitho case represents a mixed picture.

It needs to be admitted that the Vadera case is difficult to judge, and indeed is so regarded by the experts in medical law (cf. Goldberg, 2000). However, it is unclear why the core question of the case ("has the GP prescribed the pill to a patient suffering from sustained hypertension?") was not posed. Certainly, the students have a strong intuitive opinion about the GP's behaviour, namely that the GP has failed in her duty of care. However, the verdict reported with the case should have led them to question that intuitive judgment, and the elements for posing the core question are included in the case description. The additional information includes the judges' opinion that he was not satisfied that Mrs. Vadera suffered from hypertension. This information did not prompt puzzlement or inquiry, but rather was dismissed as simply being incorrect. This information should have prompted the students to pose the question why it is one of the core contributions to the judgment, and it remains to be investigated why this additional information did not have the desired effect. It appears that the judge's reasoning is too far removed from the students' definition of what is 'negligent' behaviour (intended as, in the students' words, 'unprofessional', 'naïve' or 'sloppy').

In sum, the additional information (the expert opinion and explanation) did not have the effect it was designed to have, and a generic requirement of adding an expert explanation must be adapted better to the students' preconceptions and the case. In a sense, the failure to pose the core question on the Vadera case needs to be considered a failure of the learning design.

It could be argued that a task explicitly asking for the identification of the core question may have led to conceptual change, and to a better performance in the discussions. Also in this respect, the learning design may have been deficient.

Another factor that may have contributed to the failures with the Vadera case is the sequence of presentation. The case was presented first, and the students may have required some time to familiarise themselves with the study situation and the domain. Further, the Vadera case, being the most difficult one, should be presented as the last case so that the students may make use of their earlier conceptualisations. It is indeed possible that by discussing the Chester case, the students have become more familiar with the specifics of legal reasoning, not only with the concepts of medical law themselves. Having experienced the fruitfulness of posing a single core question, they may have focussed on the single core question of the Vadera case.

The opportunity to look back at an earlier solved case to solve a current one was indeed not promoted by the study design, though it should be pointed out that the difficulties the students would have with the different cases was not assessed when the sequences was specified.

The performance on the Chester case is quite surprising because it requires establishing a causal connection between the extent of the warning and the patient's decision to have surgery. This is a somewhat atypical causal relation: causal relations are normally established between actions and events. Nevertheless, the students seem to interpret the role of causality in judging cases of liability flexibly enough.

The discussions on the Bolitho case were the most productive ones in terms of conceptual change. Two out of 4 groups correctly identified the case as revolving around the question whether the clinical intervention should have been made, a question that is determined by the Bolam test. However, understanding the importance of the Bolam test does not require a substantial reorganisation of the aspects of the case. Rather, this conceptualisation only solves the problem of how to interpret the single most important aspect of the case, namely the physician's claim that she would not have carried out the clinical intervention even if she had attended the child. In a sense, then, the Bolitho case represents a rather low challenge to the students.

In sum, the cases chosen for the study represent a mixture of complexity and difficulty with neither being an 'ideal' case. The performance is determined by several factors. The factor most relevant for the framework within which the study was conducted is the description of the case and the task. These two factors will need to be disentangled in future studies. For example, it is possible that the task assigned with the Vadera case should have asked specifically to "identify the core question". It is also possible that additional information or even a different presentation of the same information may have led to a better performance. The Chester case appears to be too easy to solve, while the Bolitho case does not require major restructuring. The experiences with the cases, and their characteristics together with the considerations should be taken into account when using cases as the bases for small-group discussions on medical negligence and liability.

8.3.6 Summary and conclusions

The aim of this study was to test whether the learning design and especially the description of the cases and the tasks assigned to the students would produce the desired form of learning. To reiterate, the case descriptions were augmented with expert opinions and explanations so as to provide a model of expert conceptualisation. The task assigned was meant to promote the understanding of how an expert would judge the case.

The results show that the learning design is only partially successful. It appears that success or failure in the study depended most strongly on the cases themselves. Specifically, the Vadera

case represents a particular challenge to the students, though a conclusion about the general inadequacy of the Vadera case for the studies cannot be drawn. On the contrary, the strong contrast between a lay and a legalistic conceptualisation would be emphasised if the students had been able to understand the core question. The difference between these conceptualisations is less apparent when no intuitive and strong lay conceptualisation is possible (such as in the Chester case).

In sum, the study has led to several insights into how to improve the proposed learning design:

- a task explicitly asking students "to identify the core question" rather than the task of proposing and justifying a verdict may have led to better learning. This task would focus the students' efforts from the beginning to construct a single all-encompassing conceptualisation. This task would also implicitly tell students that cases of medical law are solved by answering a core question
- the sequence of the presentation of the cases will need to be decided according to the difficulty to conceptualise the cases. The sequence used in the study is counterproductive in that it presents the most difficult case at the beginning. This design does not promote 'looking back' at an earlier conceptualisation and does not help the students to acquire the correct meaning of the concepts gradually
- the selection of the cases will need to be made on the basis of the possibility that the students have an strong intuitive opinion about a case. Though it is desirable that students recognise the differences between the conceptualisations, a strong lay conceptualisation may require additional information

8.4 A study on collaborative learning from reusing earlier solved problems

8.4.1 A design variation: prompting the reuse of earlier solved problems

The study presented here is the second local implementation of the learning design proposed in chapter 7. The study implements a small variation of the design: tests specifically analogical learning (described in section 3.3.4) through the cuing paradigm where learners are explicitly asked to look back and reuse an earlier solved case to solve a current one.

The design envisioned a form of learning that occurs with some reuse of other cases, evidence of which would be provided by concrete reference to other cases during the discussion and ideally the adaptation of conceptualisations of other cases to current one. The design sought to

promote this form of learning by selecting cases that share structural commonalties, and differ in their surface features. The cases chosen do indeed share a common 'type': they are cases about the omission of a clinical intervention. In the Vadera case, the GP does not verify her initial diagnosis, in the Chester case, the surgeon keeps back information about the risk of the surgery, and the Bolitho case is clearly characterised as a case where an intervention that should have been carried out was not. It is evident, however, that the learners do not make any references to these cases, nor do they mention any structurally similar cases from their own experience or knowledge (e.g. cases that are in the public domain).

A clear explanation for the absence of remindings and reuse cannot be given, since no data that would help giving such an explanation have been collected. However, it can be argued that the typification into cases of omissions of clinical actions does not bear strongly on how to conceptualise the case nor does it suggest a straightforward 'solution' to the cases. Though such cases render the question of causality all the more difficult to decide – the question about 'what would have happened if something was done' – a similar question is asked in cases where a clinical action did lead to some harm. Hence the typification of the cases is of only relative usefulness. Hence, despite the cases sharing a structural commonalty, that feature does not lead to a common and hence transferable conceptualisations

This absence of explicit references to other cases and the absence of learning from reusing other cases provide a further rationale of the variation of the learning design, presented in the next sections. The remainder of this chapter will present a variation of the original design conceived to address the absence of that form of learning that the design was supposed to promote: learning from reusing structurally similar cases, in other words, analogical learning. While a clear identification of the reasons of the absence of this form of learning with the cases of medical law would certainly provide the proposed variation a strong basis, the novel design relies again on the framework exposed in chapter 3. In that framework, the role of earlier examples in problem solving and learning has been emphasised, and in particular the mechanism of reuse described extensively.

Reuse is the broad problem solving phenomenon of analogical learning, a form of learning that is recognised as being the core mechanisms of the acquisition of expertise (see section 3.3.4). Reuse with explicit instructions is studied under the cuing paradigm (Ross & Kennedy, 1990), and studies using that paradigm have shown that indeed reuse forces a small amount of generalisation over the two examples. A further condition of reuse is clearly that the past solution can be adapted to the current problem (analogies are computationally intense), and that the solution satisfies pragmatic constraints of the current problem.

To satisfy these conditions, the design proposes to vary the task and the domain. Specifically, the domain chosen for the study, software engineering, permits a clear structuring and assignments of roles of the components of its problems and examples. The task implements the cuing paradigm, i.e. the students are told to reuse the earlier example. The following sections describe the study in details.

8.4.2 The study

8.4.2.1 Material

Two main requirements were considered for the choice of the two examples used in the study. First, and most importantly, the material used for the studies needed to allow a neat separation between surface and structural features, which means that the problems needed to differ substantially in surface features, but would require the application of the same principle to be solved or understood; and second, the material should be sufficiently complex to make it likely that an initial understanding and abstraction of the example would be incomplete. Examples of software pattern implementations satisfy well these and other subsidiary practical requirements. A description of them is as follows (from Ince, 2000):

> Software patterns are prescriptions for programmers to satisfy desirable software design properties. These prescriptions affect how a program is organised and also give concrete hints about how to implement a program.

The programs we used were implemented to allow 'extensibility', i.e. to allow easy modification and update of an existing software package without the need to recompile core parts of the package (such as base class definitions).

The requirement for extensibility of a program can be deduced from the description of the life cycle of software. For example, if the project is to be implemented in stages, software extensibility is desirable since new parts of the program can then be added without requiring change to the already implemented parts.

Both software projects engender the same problem (i.e. extensibility) and share structural relations between kinds of elements. Specifically, they both contain objects that reflect real-world entities and both implement two main types of operations, 'output' operations and 'managing' operations, where only the former will need to be extended. This distinction is crucial to implementing the pattern (and is defining for it): while 'managing' operations are implemented in a traditional way, 'output' operations are implemented in a way to allow extensibility of them.

It is expected that the students to acquire an abstract representation of the first example, most probably a quite general problem-solution schema. However, this schema can be acquired without considering the distinction mentioned above, and therefore, the schema would be insufficient to recognise fully the similarities between the case and the problem and to transfer the solution. Upon trying to solve the problem, the students would realise that their schema is incomplete and thus re-analyse the case. Mapping plays a significant role during this adaptation: the students need to put into correspondence the elements of the software projects as they are specified in the description -and relate these elements to the implementation, and then adapt the implementation. It is expected that re-analysis and mapping results in an update and refinement of the initial schema, and that in this way the students gradually learn the pattern.

8.4.2.2 Subjects

Three students from the second year of an undergraduate course in Computer Science at University College London participated in the study. The students had all obtained grades in the top 10 percentile of marks in their first year computer programming course. They were paid for their participation. None was familiar with software patterns. The students had not known each other before participating in the study.

The students solved the problems in collaboration using the same purpose-built Internet-based system used for study 2 (the study on medical law).

8.4.2.3 Procedure and data collection

The study was separated into three stages: familiarization with the first example; solving the second example; probing the students' acquired knowledge. In the first stage, students read a description of the first program and they then carried out 4 tasks that and allowed them to become familiar with the program (see figure 55).

In the second stage, the problem solving stage, the second program was presented. The task consisted in changing the architecture of the program to conform to the requirement of extensibility (see figure 56). In this stage, the students could access all material of the first example easily through hyperlinks. To trigger reuse, they were only told "the two problems are similar". In the third stage, the students' knowledge was assessed through an interview. The interview assessed the students' understanding ("explain how the implementation achieved extensibility") and memory.

During the learning session (i.e. the 1st and 2nd stage), the system recorded all behaviours, i.e. messages written in the chat and the content of the whiteboard, on a text file. All solution proposals, discussions, explanations and so on were made across the chat facility. The

whiteboard was only used to provide the concrete solution (i.e. the updated architecture and code of the second problem).

Data from the interview are not discussed separately here, but are presented selectively to augment the data gathered from the learning session.

In the main file, some methods produce outputs, 6 of them are displayed in the 'output' section (follow the hyperlink). Your task is to describe how these methods produce the output by using the classes.

Please specify the following for each stage of the processes:

- **which method is called**
- **what argument(s) is(are) passed to it**
- **what objects are created/used**
- **what is the state of these objects (value of field variables)**

Figure 55. Task context of the 1st stage.

The following code snippets implement a small banking system that allows input of information and their display. The bank distinguishes between types of customers, and the system elaborates input and outputs information depending on the type of customer. There are two main types of customers: companies and private customers.

After the initial code has been written (the one you're given here), the bank, i.e. the future owner of the system, decides that it might want to make available its data to outsiders. Since it is not yet clear in what form this information would be needed, the bank asks the programmers to implement the system initially in a way so that in the future such operations can be added without re-compiling and re-deploying the

Figure 56. Task context of the 2nd stage.

8.4.2.4 Analysis of the protocol

The reading of the protocol focused on highlighting two aspects of problem solving: first, that the students would generate a new functional explanation of the first problem and that the content of this explanation is strongly influenced by the second problem; and, second, that the structure of the second problem would influence how the first problem is structured. With 'structural knowledge' we mean knowledge about what elements the program has and how they are related. The chat messages were analysed by decomposing them into the following categories[14]: similarity statements, explanations, solution (proposals) and structuring. We

[14] The analysis focused on the content of the chat. Data from the whiteboard was consulted for analysis when messages in the chat referred directly to a figure drawn on the whiteboard. Task messages or other non-content communication messages (such as "should I write the solution on the whiteboard?") were not considered further.

differentiated these types further by classifying them according to what source of knowledge was mentioned in the message. The sources of knowledge that have been taken into account are: background knowledge, details of the examples and abstract knowledge gained by re-analysing the 1st example. Only the 2nd stage, i.e. the problem solving stage, was analysed with this scheme as a base. The 1st stage was analysed only to distinguish the abstract knowledge that the students acquired while carrying out the familiarization tasks of this stage. This analysis was necessary to distinguish between abstract knowledge gained in this stage and abstract knowledge gained from re-analysis.

This analysis would provide with insights into the relation between the kind of utterances and the sources of reference. The reasoning behind the analysis was that explanations of the first problem that contained an explicit reference to the second problem would confirm the assumption that these explanations are made by taking into account the second problem. Solution proposals that referred to abstract knowledge gained from re-analysing the first problem or to details of this problem would show its influence on solving the second problem. The quantitative characterisation was restricted to summing the occurrences of these two sub-types and presenting them as a percentage of the total of the type.

8.4.2.5 Results

Quantitative results

From the analysis resulted that almost all (14 out of 16, 88%) re-explanations of the first example's implementation contain some reference to the second example. Similarly, many (11 out of 18, 61%) proposals for solving the second problem contain references to the first problem.

The students did not perform equally well in problem solving. Rather, one student (Sam), contributed most of the messages indicating understanding and explanation. This imbalance slowed the problem solving considerably. However, all students gained a sufficient understanding of the pattern and participated in equal amount to the concrete coding of the solution. The following paragraph describes the students' problem solving, reporting details from the protocol.

Extracts and interpretations of the protocol

Similarity between the two examples is initially established on the base of the common problem. In the first stage, the students understood that the implementation features a technology called 'indirection'. Indirection is a means by which the same function can be called with different parameters thus exhibiting different behaviours. Indirection can be used to

implement extensibility, and this notion provides the anchor by which the two problems are seen as being similar.

307	Sam	we need another method (func) to provide the extra indirection we need
308	Sam	func can be overridden
316	Sam	for minimal recompilation can we recompile just one class, and maybe add new ones
317	Andy	oh okay, so we create a method func that has an Object argument
325	Peter	yes, of course, it's Visitor that does all that!
333	Sam	Files and Directories are subclasses of Customer
337	Sam	All getter/setter and new operations are in subclasses of Visitor
338	Sam	metaphor
340	Sam	trying to draw parallels between the problems
389	Sam	we subclass StuffDoer to add operations
400	Peter	StuffDoer is the Visitor
404	Peter	so we'd have the stuffDo method here

Figure 57. Extracts of chat messages. The numbers on the left indicate the line number with respect to the whole protocol.

The initial solution proposals focus on transferring the 'indirection' solution element to the second problem (see figure 57, lines 307 and 317). This simple adaptation fails, because the students' knowledge about indirection is confined to applications where the type of parameter is known in advance. The problem description, though, specifies clearly that the type of parameter is still unknown. Hence, the students reanalyse further the first example and see the relevance of the Visitor hierarchy for the core purpose of the implementation (line 325). This prompts them to look for correspondences between the examples that are generally in terms of 'what things are' (line 333). Mapping is used explicitly as a problem solving approach (lines 338, 340).

While re-explaining the first example and setting correspondences between the examples, the students generate a coherent schematic representation of the pattern implementation, rather than 'blindly' copying over parts of the implementation one by one. In other words, their efforts centre on understanding the implementation, rather than on problem solving. The generated schema is notable as its elements are identified through names that reflect the functionality of

the solution elements. For example, the students rename the Visitor hierarchy as 'StuffDoer' (line 389), a term that is indicative of the role of the Visitor hierarchy. The method func(), whose function is to invoke all other methods through the Visitor hierarchy, is renamed doStuff() (line 404), a name that, again, reflects its function and role in the Visitor pattern.

The schema provides the basis for the solution. In fact, once the students are satisfied with the explanation of the first example, they implement the second example quite straightforwardly. As an informal analysis of the content of the whiteboard reveals, the students seem to resort to the strategy of copying implementation details from the first to the second example, simply substituting names. Though this observation indicated that the schema lacks knowledge about the details of the implementation, it shows that knowledge about what kind of elements there are might also be contained in the schema. This knowledge is in fact necessary to individuate those parts or elements of the first and second example that need to be, respectively, copied and changed. Support for this interpretation derives from the interviews wherein only one of the students was able to recall the details of the implementation and was able to recall specific examples of code, while all students could recall the basic elements of the examples and the functions of elements of the solution.

It can hence be assumed that the process of reanalysis resulted in imposing a structure on both examples, which implies that the earlier example has been restructured (our second claim). During stage 1 the students notably fail to make significant differentiations between the methods and the object hierarchies. For example, when asked to describe the program, they say "there are several methods that do things", and "there are two object hierarchies". During stage 2, however, they classify the methods into 'getter' and 'setter' methods (line 337) and differentiate the two hierarchies (line 478), as one of them is to be extended, while the other is not.

When the elements are so differentiated, the students notice that this differentiation is already hinted at in the description (line 511). For example, the description says "that no new types of objects the system operates with are to be added, while the system's functionality might be extended in the future". This description implicitly differentiates between the two hierarchies.

Discussion of the protocol data

A critical focus of the second stage then was reanalysing the first example and generating a schematic representation of that implementation. About the content of this schema can only be speculated. However, the naming in terms of the role of the schema's elements might be indicative that the schema contains knowledge about the elements' function in the overall pattern, and knowledge about how they interact. Further, knowledge about the kinds of elements seems to be contained in the schema. It is however especially the functional contents of the

schema that might allow the conclusion that it is generated to provide knowledge about how to solve the second example. In fact, a functional representation of the pattern where the details are omitted serves as a good basis to solve the problem: the schema contains knowledge that is at that level of abstraction that allows a straightforward solution. It is likely that the characteristic of the schema as being an explanation and an implementation proposal at the same time, implies that re-analysis of the first problem focused on providing an abstract representation suitable for problem solving. In other words, reanalysis is demand-driven.

The second claim to be verified by the study, that the first example would be restructured by exposure to the second problem, is more difficult to substantiate, but it is likely that the differentiations mentioned above provide some evidence for it. Similarity between the two examples plays a significant role in restructuring. In fact, a precondition to transfer the implementation is to map the elements of the two systems: 'Node' must be mapped to 'Customer', 'Size()' to 'DisplayData()', and so on. The structural similarity (i.e. Size() is a method of 'Node' and DisplayData() a method of 'Customer') highlights the similarity of kinds: the students see that the 'Node' hierarchy and the 'Customer' hierarchy reflect entities in the real world, while the 'Visitor' hierarchy does not. In addition, and most importantly, they distinguish between 'getter' and 'setter' methods and classify the methods in one or the other of these two categories.

Recognizing the structural similarities is aided by the descriptions of the two systems given in the task briefings, where all of these differentiations are already pointed out. In the first stage however, they have been overlooked. It could be claimed that, throughout the session, the students also learn to relate the descriptions to the implementations. This form of learning might result in the ability to recognize structural features in problem descriptions that is a significant aspect of proficient problem solving and expertise (cf. Chi et al., 1981).

8.4.2.6 General discussion

It is generally agreed that learning from analogy involves abstraction over the surface aspects of structurally similar problems. This study confirms these general assumptions about analogical learning, but allows also some insight into the nature of the process. Specifically, analysis of the protocol allows us to conclude that these abstractions are created strategically (cf. Reeves & Weisberg, 1994) and result from re-analysing an earlier problem in the context of a new problem needing solving. It has been found that the form of this knowledge is mainly functional, i.e. it is at a level of abstraction and of a form required for the solution of the current problem, from which it is concluded that the abstraction is demand-driven. The generated schema also contains knowledge about the kinds of elements constituting an example and about

the relations between those elements. As such it resembles the kind of problem-solution schemas that characterize a good problem solver (cf. Chi et al, 1981).

This knowledge is emphasized as a result of mapping the examples. For example, during the interview one of the students described a method as "this method is a 'getter' method of that base object". Knowledge about kinds and relations might have existed before the learning session, as, in fact, they are part of the students' domain knowledge. However, during the comparisons of the examples, this knowledge is aligned and thus emphasized (cf. Gentner & Markman 1997). The comparison forces a restructuring of the first example, revising the structure acquired during the first stage.

The qualitative nature of the descriptions of the examples in the interview allows us to speculate that domain-specific knowledge about kinds and relations is also part of the examples, i.e. it became integrated with the details of examples during the learning session. It might therefore confirm Ross' assumption that, from an analogy, details and abstract knowledge of examples become part of single knowledge structure (cf. Ross & Kennedy, 1990).

The findings might have implications for models of experiential learning where example comparisons and analogy feature prominently as learning mechanisms (cf. Gentner, 1989). It is proposed here that the process of reanalysis might be an important part of such models. Specifically, as an extension of models of learning from example comparisons, it can be assumed that abstract knowledge developed over a complex problem is initially incomplete, and that abstraction will continue with subsequent uses of this case for problem solving. Upon reusing a case, re-analysis of it occurs: the case is analysed to extract information that is deemed to be useful for the solution of the current problem. Hence, learning from cases is gradual and might entail reanalysis of memorized cases. An entailment of this proposal, and one which is clearly supported by these data, is that the details of particular examples are retained even after abstraction (cf. Ross, 1987; Ross, Perkins, & Tenpenny, 1990). This 'conservative' mode of abstraction is clearly essential in complex domains, if experiences may be understood only partially until a subsequent problem solving episode re-invokes their analysis.

In sum, the resulting model of learning from analogy in complex domains makes three central assumptions: first, students solving a problem without access to similar cases for reuse nevertheless acquire some abstract knowledge over it: abstraction is immediate, but partial. Second, once the students have available a similar example for reuse, establishing correspondences between a current problem and an example is a major source of acquiring abstract knowledge that encompasses both examples: mapping produces rich abstraction and is demand-driven. Third, the incompleteness of earlier acquired abstract knowledge triggers re-analysis of the stored cases; since re-analysis operates on the details of a past case and is driven

by the specifics of the current problem, relevant aspects of a case that have remained unnoticed might now be noticed: i.e., learning evolves through re-analysis, and reasoning with analogies therefore occurs in both forwards and backwards directions.

The study has shown that prompting students to look back at an earlier solved case to solve a current case can lead to significant insights into the structural similarity of isomorphic cases, and to the acquisition of more expert-like domain-specific concepts. The effects of the generic mechanism of learning from reuse are well known in the literature, and some research has implemented the cuing paradigm as a training regime. For example, Podolefsky & Finkelstein (2006) showed that instructing students to solve undergraduate physics problems analogically increased their understanding about physics concepts. However, classroom-based implementations of the cuing paradigm have remained rare, and confined to the domains of physics and biology (Newby, Ertmer, & Stepich, 1995). The study described here extends the use of the cuing paradigm to software engineering, and provides a first testbed of this extension.

The study must be seen also a successful implementation of the learning design, albeit of a specific variation of it. The learning success has shown that it is possible to engineer a specific form of learning by carefully selecting the learning material and the learning task. The design specified especially the match between the cases: the solution of one case can be adapted to another case, and this adaptation results in schema abstraction. Other factors influencing learning are rather subordinate to the effect of the material, though certainly that task has a major impact on learning (it should also be pointed out that the students strayed minimally from the task). In sum, the study confirms the hypothesis that reuse of earlier solved cases can lead to significant if the material is appropriately designed. Clearly, a major new research direction emerges from the study: to focus on the design of the material rather than other components of a learning design to achieve major learning gains. Whether such a careful matching between cases is possible also in other domains remains to be investigated.

8.5 Summary and conclusions

This chapter has presented two studies implementing the learning design proposed in chapter 7. The aims of the studies are to illustrate how the design can be implemented in a specific educational setting, to assess whether the learning design promotes the form of learning sought, and also to derive new insights into how to improve the design. The results of the study on medical law show that the design specification requires a more careful local adaptation to the specific educational situation. In particular, the generic requirement of including expert opinions

and explanations with the description of the case events must take the students' lay conceptualizations into account. For example, the additional information given with the Vadera case did not promote the students' puzzlement and questioning about the significance of that information, but rather was dismissed. The students failed to see the importance of that information because they could not incorporate it into their own conceptualisation. It can also be speculated that the tasks assigned to the students, to propose their own verdicts and justify them, has not helped re-conceptualizing the cases. The task appears to entrench the students further into the own conceptualisation rendering the adoption of a more expert conceptualisation more difficult. It is likely that a task asking explicitly to reason like an expert may have led to better learning. In the specific contexts of the cases on medical law, such a task would be to "identify the core question of the case that the court needs to answer". The students' performance on the Chester case, where the question was answered spontaneously, shows that they would be able to pose the question, and recognize the importance of posing this question for judging a case.

The second study implemented a variation of the learning design: rather than asking only for an interpretation, the students were also explicitly told they should reuse an earlier solution to solve a current problem. The study shows that this additional task promotes the abstraction of commonalties of the isomorphic cases, and the students acquire abstract knowledge (a problem – solution schema) that encompasses both cases. However, a claim about the generalisability of the efficacy of the cuing paradigm must take the domain of the study into account. The adaptation to other domains, and especially medical law, would require first identifying the isomorphism underlying the similarity of cases. For example, the medical law cases are of the same kind, but their structural similarity is limited. An aspect to be exploited by an explicit task is the generic approach to conceptualise cases of medical law, namely the requirement to identify a single core question and answer it with the information available. Also in this respect, the generic design specification requires a better adaptation to the specific characteristics of the learning situation.

Chapter 9

Re-conceptualising co-construction: a case study

9.1.1 Introduction

Chapter 8 has focussed on the question on whether there are observable changes in the students' conceptualisation of the cases. This question is essential to assess whether the design proposal (chapter 7) has indeed led to a form of learning that it is designed to 'engineer' and that was notably absent in the small-group discussions on the euthanasia cases (chapter 6). The results of the analysis have shown that some groups learned to apply the concepts of negligence and liability correctly to the cases, and do conceptualise the cases correctly (see table 8). An answer to the question about *how* the correct conceptualisation is constructed is answered in this chapter. These sections present a case study of one particular exchange of the main study presented in chapter 8 (the discussions centring on cases of medical law) that illustrates how one peer constructs a novel and correct conceptualisation by reusing knowledge introduced earlier into the discussion by other group members. The case study relies on the assumptions that have guided the research presented in the previous chapters, but extends the notions of co-construction and joint construction of knowledge to include in the analysis the notion of partial

conceptualisation. That is, the case study shows how a partial conceptualisation of the case proposed by one group member is the basis for a complete and correct conceptualisation proposed by another group member. The study also shows that the mechanism of producing a complete and correct conceptualisation from partial ones is the mechanism of reuse: the students reuse knowledge available externally, specifically those displayed in the chat window. The mechanism of reuse is to be seen within the hypothesis of equivalent access (Perkins, 1993): knowledge available externally or internally (i.e. a student's own knowledge) can contribute equally to the construction of the novel conceptualisation.

The analysis results in the general claim about the mechanism of learning in groups being both individual and collaborative, and in particular in a claim of joint construction resulting from the reuse of structural and surface knowledge deployed into the discussion by other peers. The case study is a microanalysis of a discussion of group 2 on the Chester case (see section 8.3.3 and appendix 9). The study will be presented discussing more in depth the pertinent concepts of conceptual change and collaborative learning firstly introduced in chapters 2 and 3.

9.1.2 Individual and collaborative components in co-construction

This case study will provide an illustration of the mechanism by which new conceptualisations are generated within the individual learner through reinterpreting the learning material (i.e. learning is individual), but the contributions to the dialogue made by others provide knowledge that is reused and re-interpreted (i.e. learning is also collaborative). In the microanalysis of a collaborative learning dialogue that follows, it is shown that a new conceptualisation is created that correctly re-interprets knowledge previously used in different conceptualisations. It will be shown that surface as well as structural knowledge introduced earlier is reused in a new conceptualisation of the case.

9.1.3 The Chester case: legal and ethical perspective

An analysis of the case discussed by the students was presented in section 8.3.3. There, the conceptualisation of the case in terms of the correct legal interpretation of negligence and liability was presented. That appropriate conceptualisation (the 'negligent liability view') concerns responsibility for the harm suffered by Ms Chester and specifically whether failing to inform Ms Chester caused the harm. However, alternative conceptualisations are possible. The one described here is one adopted initially by two of the students, and later replaced by another one. This other conceptualisation (the 'ethical view') focuses on the failure of the surgeon to obtain informed consent from the patient. The requirement to obtain informed consent for clinical interventions derives from ethical principles, primarily from the principles of autonomy and non-paternalism. It embodies the notion that a patient has the *right* to be fully informed

about his medical conditions, clinical interventions, etc., even if it may not be in the patient's best interest.

The analysis of the exchange discussed in this case study has shown that the students may interpret the case in terms of ethics rather than law, and that these different 'viewpoints' or perspectives bear on what they learn from the case.

9.1.4 Description of the analysis

The claim rests on the kind of analysis identifying conceptual change described in sections 5.4 and 8.3.4. To reiterate, the analysis identifies the conceptualisation throughout a discussion in order to evidence changes in that conceptualisation. The analysis targets whole utterances that may reflect that conceptualisation, focussing especially on utterances that show whether the students have posed the correct question. The analysis focuses also on the students' interpretations of the aspects, and specifically whether they assign those aspects the correct relevance and role.

A novel analysis is however also applied to this exchange: an analysis that identified the argumentation structure of the dialogue. Utterances were categorised into claims, counter-claims, confirmations and elaborations. This analysis is auxiliary only: it is used to identify which of the two positions position (the ethical or legal view) is adopted by the students. It is assumed that utterances confirming, criticising and elaborating an earlier utterance is evidence that the contributor has adopted or accepted the view expressed in that earlier utterance. Proposing a new conceptualisation would not occur within a typical argument structure, but indeed appear as a novel proposal.

A special category, outside an analysis of the argumentation, 'conceptualisation' identified those contributions where one of the two alternative conceptualisations was conveyed so clearly as to warrant the inference that conceptual change had occurred.

A third analysis identified the topical relations between the units pertaining to different utterances. The relationships considered were: structural (whether an utterance expresses the same conceptualisation of an earlier utterance), partial-structural (whether an utterance expresses a conceptualisation that contains partially a structural element of a previous utterance), and surface (whether a surface element, i.e. a fact of the case, is repeated in subsequent utterance). The aim of this analysis was to derive a picture of the topical relationships between the content of one utterance (including only parts) and the content of a subsequent utterance. Based on this analysis, speculations about the influence of earlier utterances on subsequent ones were made.

#	time	reference	Message	moves
77	14:43:44		Erin: I think the doctor has failed to achieve appropriate consent	conceptualisation (judgment)
78	14:44:00	77 (77)	Claire: the risk was small 1-2%	countering 77
79	14:44:06	77 (77)	Susan: he got consent, just not an informed one	elaborating 77
80	14:44:18	77 (79)	Claire: he must have had the consent	countering 77
81	14:44:31	79 (80)	Claire: informed but not well enough informed	countering 77
82	14:44:45	78 (81)	Susan: even risk of death from GA is small, but patients have to be told all the same	countering 78, confirming 77
83	14:45:28	82 (82)	Erin: exactly he didn't fulfil the criteria of legal consent. i.e. the patient should understand the risks involved be able to weigh then in a balance and recall them.	confirming 77
84	14:45:30	82 (82)	Claire: but if she had been told the risks and heard that there was only a 1-2% chance that it would go wrong, she might have dismissed it thinking that it probably wouldn't happen to her	countering 82
85	14:45:47	(83)	Susan: do you think that the patient should be told of every possible risk?	
86	14:45:49	84 (84)	Erin: but there is evidence of her aversion to surgery	countering 84
87	14:45:55	85 (86)	Erin: yes	confirming 83
88	14:46:21			
89	14:46:25	87 (87)	Erin: definitely need to know every risk to be able to make an informed decision	confirming 83
90	14:46:31	(87)	Susan: so had she known of the risks, she would have continued to suffer from chronic back pain	(new) conceptualisation
91	14:46:48	90 (90)	Erin: that would be up to her	
92	14:47:09	89 (91)	Claire: patients should be told all the risks, but some risks are so small that there's no point emphasising them too much otherwise you'll just end up worrying the patient (probably unnecessarily)	countering 89
93	14:47:26	(92)	Susan: she had a fear of being crippled, had an aversion to surgery, the risk of impairment from the surgery was small	
94	14:47:27	(92)	Erin: and then she wouldn't be complaining now as she would have fully consented to the surgery and understood the risks	
95	14:47:47	(94)	Susan: it seems to me that the doctor was trying his best to get her to have the operation	
96	14:48:26	94 (95)	Susan: true	
97	14:48:33	95 (95)	Erin: but at the end of the day it is not the doctors right to decide whether she should have surgery it is her decision	countering 95
98	14:48:39	(96)	Claire: do you really think that she would have refused the operation even if she had known the risks?	

Figure 58. The dialogue analysed in this chapter. The dialogue is of group 2, and was one of the three dialogues showing a marked difference in conceptualisation, i.e. conceptual change. The table columns reproduce (from left to right): line number; time stamp; line number the contribution most likely refers to, and earliest visible line (in parentheses); contributor and contribution; augmentation moves

9.1.5 Analysis results

9.1.5.1 Introduction

The analysis of the dialogue is best introduced by describing the views taken by each of the three students – Erin, Claire and Susan – because the dynamic between the different views is central to the claim for the reuse of knowledge.

The essential dynamic is simply described as follows: Erin proposes, in the first contribution to the dialogue, a judgment of the case based on its conceptualisation in terms of informed consent. Susan, while initially accepting and contributing to that conceptualisation, changes, at the end of the first half of the discussion, radically her view of the case, and correctly applies the concepts and conceptual relations pertinent for negligent liability. Claire contributes more significantly than Susan to Erin's conceptualisation, but analyses it critically, and by doing so, furnishes Susan with structural knowledge upon which Susan then builds her new conceptualisation. Claire, in contrast to Erin, also internalises Susan's new conceptualisation towards the end of the discussion. First, Erin's view of the case is described.

Erin

Erin opens the discussion by introducing the concept of informed consent to conceptualise the case (figure 59). As described earlier, this conceptualisation relies on ethical principles and is complementary to the 'legal view' that the students *should* adopt. She concomitantly judges the surgeon's behaviour by appeal to this view. Though this remains implicit, her use of the term 'failed' indicates that she intends a 'guilty' verdict. As will be seen, the implicit judgment serves as the referent for several subsequent contributions.

77	**14:43:44**		**Erin: I think the doctor has failed to achieve appropriate consent**	**conceptualisation (judgment)**

Figure 59.

Erin implicitly refers in her first and subsequent contributions to the clinician's duty to inform patients about their treatments (83, 89 and 97, figures 60 to 62).

Erin's view is therefore not incorrect, but rather misplaced. Erin grounds her view of the case in terms of the obligation of obtain consent and the right to be informed from which it derives, rather than considering the notions of causality and liability. She proposes this view in the first contribution, and maintains it throughout the discussion: she, in contrast to Claire, does not internalise Susan's new conceptualisation (lines 89 and 97, figures 61 and 62).

83	**14:45:28**	**82 (82)**	**Erin: exactly he didn't fulfil the criteria of legal consent. i.e. the patient should understand the risks involved be able to weigh then in a balance and recall them.**	**confirming 77**

Figure 60.

89	**14:46:25**	**87 (87)**	**Erin: definitely need to know every risk to be able to make an informed decision**	**confirming 83**

Figure 61.

97	**14:48:33**	**95 (95)**	**Erin: but at the end of the day it is not the doctors right to decide whether she should have surgery it is her decision**	**countering 95**

Figure 62.

Susan

Susan proposes in contribution 90 (figure 63) the alternative conceptualisation based on the concept of the negligent liability.

90	**14:46:31**	**(87)**	**Susan: so had she known of the risks, she would have continued to suffer from chronic back pain**	**(new) conceptualisation**

Figure 63.

While contribution 90 refers only to the aspect of 'knowledge about the risk' and the possible condition that patient would have continued to suffer if she had not consented to the surgery, the underlying conceptualisation incorporates the notion of causality. Susan, implicitly, says: "if the patient had known more about the risk then she would not have consented to the surgery and the harm would not have occurred". Clearly, the patient's knowledge about the risk relates to the surgeon's warning, a relation that is again implicit in Susan's contribution, but can be coherently added to the existing structure (see figure 72). On the advent of Susan's contribution and its underlying conceptualisation rests the claim made in this chapter.

Susan's contributions preceding utterance 90 show an initial acceptance of Erin's conceptualisation (79 and 82, figure 64 and figure 65). Contribution 85 is interpreted here as a proposal mediating between Erin's and Claire's dispute (figure 66), and is evidence that Susan has not yet generated her new conceptualisation. It is therefore within Susan that the change between one view of the case (informed consent) and another (based on negligent liability) occurs.

79	**14:44:06**	**77 (77)**	**Susan: he got consent, just not an informed one**	**elaborating 77**

Figure 64.

82	14:44:45	78 (81)	Susan: even risk of death from GA is small, but patients have to be told all the same	countering 78, confirming 77

Figure 65.

85	14:45:47	(83)	Susan: do you think that the patient should be told of every possible risk?	

Figure 66.

Claire

Claire switches between the views established by her peers. She initially embraces Erin's view, but remains critical of it. Claire's contributions are mostly counter-claims to Erin's conceptualisation, but occur within the view of informed consent. They are shown here in context.

77	14:43:44		Erin: I think the doctor has failed to achieve appropriate consent	conceptualisation (judgment)
78	14:44:00	77 (77)	Claire: the risk was small 1-2%	countering 77
79	14:44:06	77 (77)	Susan: he got consent, just not an informed one	elaborating 77
80	14:44:18	77 (79)	Claire: he must have had the consent	countering 77
81	14:44:31	79 (80)	Claire: informed but not well enough informed	countering 77

Figure 67.

84	14:45:30	82 (82)	Claire: but if she had been told the risks and heard that there was only a 1-2% chance that it would go wrong, she might have dismissed it thinking that it probably wouldn't happen to her	countering 82

Figure 68.

92	14:47:09	89 (91)	Claire: patients should be told all the risks, but some risks are so small that there's no point emphasising them too much otherwise you'll just end up worrying the patient (probably unnecessarily)	countering 89

Figure 69.

Claire's first contribution (78) counters the judgement entailed by Erin's use of the concept of informed consent. Claire's use of the 'smallness of the risk' is unclear in 78, but is reiterated and becomes clear in 84 (figure 68). Claire's position on the case, reiterated and evident also in 92 (figure 69), is the following: she accepts that the surgeon has violated the patient's right to information, but proposes to include, in an eventual judgement, mitigating circumstances. Specifically, she argues that since the risk is so small, there was no need to acquire informed consent.

It is crucial for the claim made here to understand that Claire, despite her proposal to take into consideration the special and mitigating circumstances, views the case in terms of the concept of informed consent, not the concept of negligent liability. Claire, as Erin, views the case as representing an issue of patients' rights and professional obligations, not an issue of responsibility and compensation for damage caused.

In contrast to Erin, Claire internalises the new conceptualisation put forward by Susan in utterance 90. Claire's contribution in 98 is clear evidence for this internalisation (figure 70).

98	**14:48:39**	**(96)**	**Claire: do you really think that she would have refused the operation even if she had known the risks?**	

Figure 70.

The next sections examine how Susan's new conceptualisation comes about, and how contributions to the dialogue preceding Susan's contribute to it.

9.1.5.2 The reuse of structural knowledge

It will now be shown that Susan's re-conceptualisation underlying her contribution in line 90 (figure 63) incorporates an element of Claire's contribution in 84 (figure 68). Claire, in 84, still maintains the view that the concept of informed consent should be applied. Claire's contribution in 84 is the strongest and clearest expression of her view. She maintains that the full disclosure of the risk may have had no effect on the patient at all, and that hence in this specific case no such full disclosure was needed. This contribution introduces structural knowledge into the discussion: Claire's contribution conveys a relation between the patient's knowledge about the risk and the effect of that knowledge on the patient's decision (see figure 71). Claire introduces this relation in an attempt to counter Erin's implicit judgment. She argues that the Chester case and others where the risk of harm is small are exceptions for which informed consent may not be needed. She accepts that the case should be discussed in terms of informed consent, but argues that, on the basis of exactly this conceptualisation, the case should be dismissed, i.e. the surgeon should not be indicted for withholding information.

The claim rests on the observation that Susan reuses the structural knowledge introduced by Claire in 84. The influence of the patient's knowledge about the risk on the patient's decision is a structural element in the conceptualisation centred on the concept of negligent liability. Susan reuses Claire's structural knowledge to generate a different structure that supports this alternative view of the case. The relation between the patient's knowledge about the risks and the effect of that knowledge on the patient's decision is indeed a structural element of Susan's conceptualisation (see figure 72). Susan's conceptualisation replaces the one that is the focus of

Erin's and Claire's arguments, but reuses a structural element introduced by Claire to support her view.

Claire's utterance in 84 influences also Susan's utterance in 90 by emphasising the decision-making role of the patient. This role of the patient is, clearly, available to the students as part of their mundane knowledge, but it is Claire who introduces it explicitly in 84. Seeing the patient as a decision maker is in contrast to Erin's view that sees the patient as someone whose rights have been violated. The emphasis on the patient as a decision-maker is taken up again in Susan's new conceptualisation. Susan generates on the basis of Claire's structural knowledge and Claire's explicit reference to the patient as a decision-maker the correct liability-centred conceptualisation. Susan's accomplishment is to be able to isolate Claire's structural knowledge from the view in which it first appeared, and insert it into a new structure.

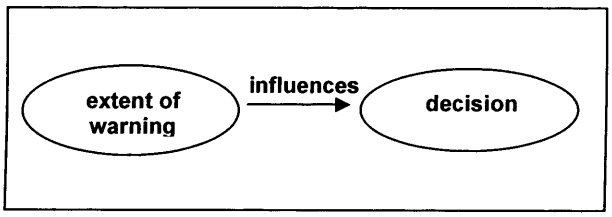

Figure 71. Claire's structural knowledge in 84

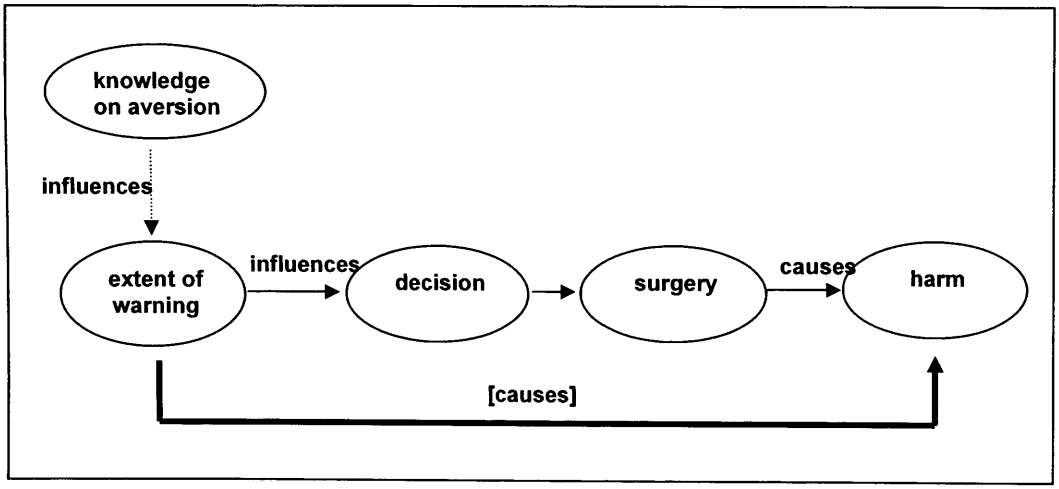

Figure 72. Susan's conceptualisation, first expressed in utterance 90, includes Claire's structural knowledge

9.1.5.3 The reuse of surface knowledge

Some utterances referring to specific aspects of the case and preceding utterance 90 also contribute to Susan's new conceptualisation. Similarly to the reuse of structural knowledge

described above, the reuse of surface knowledge entails the separation of that knowledge from its earlier use. The first contribution discussed (86, figure 73) is Erin's.

86	**14:45:49**	**84 (84)**	**Erin: but there is evidence of her aversion to surgery**	**countering 84**

Figure 73.

In this statement, Erin attempts to argue against Claire's contribution in 84. As described above, in 84 Claire argues against Erin's severity of judgment. She proposes to dismiss the case on the grounds that informed consent may not have been required, due to the low risk. In utterance 86, Erin attempts to counter Claire's counter-argument. Erin points out that, given the patient's aversion to surgery, the patient may *not* have dismissed the warning about the risk. In this utterance Erin reiterates information contained in the description of the case.

The interest in this contribution is how it was used to support a conceptualisation of the case. Erin uses the information to support her claim that the surgeon has violated the patient's right to information even more grievously given that the patient was known to be adverse to surgery. The patient's aversion to surgery and the surgeon's awareness about it have however a different role in the alternative view, the negligent liability view. The surgeon's awareness is the *cause* for withholding information (see figure 72). Clearly, his behaviour breaches the patient's rights however he decided to withhold information in order to get the patient's consent to the surgery, which was, according to his professional assessment, the best option of the patient.

Susan understands correctly the role of the surgeon's knowledge about the patient's aversion. In utterance 90, she correctly relates the patient's knowledge about the risk to the patient's decision to undergo surgery, and thus implicitly relates the surgeon's awareness of the patient's aversion to the surgeon's decision to withhold information. Evidence for this claim is Susan's utterance in 95, where she articulates that relation explicitly (figure 74).

95	**14:47:47**	**(94)**	**Susan: it seems to me that the doctor was trying his best to get her to have the operation**	

Figure 74.

To illustrate the differences between the views, Erin's response to Susan's argument in 95 is reproduced here. Erin's response in 97 is symptomatic of her persistence with the informed consent view, rather than the negligent liability view (figure 75).

97	**14:48:33**	**95 (95)**	**Erin: but at the end of the day it is not the doctors right to decide whether she should have surgery it is her decision**	**countering 95**

Figure 75.

As in her use of the aspect 'aversion to surgery', the 'risk' aspect and the aspect of the 'extent of the warning' are introduced (e.g. line 83 and 84, above) prior to Susan's contribution in 90, to provide arguments within the view centring on the concept of informed consent. Erin bases her conceptualisation entirely on the surgeon's failure to adequately warn the patient. This behaviour alone is, for Erin, grounds for an indictment, as evident by her proposition "the doctor has failed". The argumentation after Erin's initial conceptualisation focuses on the aspect of 'knowledge about the risk'. It is Claire that most forcefully uses this aspect to propose her interpretation of the case and to counter Erin's initial judgment.

Once these aspects have been explicitly introduced into the dialogue, they are available for reuse. Susan's reference to both aspects in utterance 90 is evidence that she had generated her new conceptualisation on the basis of aspects that had become the main focus of the discussion. The claim that Susan's reference to these aspects is a reuse rests on the choice of the surface expression of her new conceptualisation. Susan could have generated different surface expressions of her conceptualisation, such as "if the surgeon had fully warned her, she would..." Utterance 90 is a literal continuation of utterance 84 though the similarity is only superficial. The utterances express entirely different structures. Susan's accomplishment is again to isolate the aspects used earlier to support a different view, and insert them into a new structure.

9.1.5.4 Discussion

Two perspectives on the Chester case are evident in the dialogue: one based on ethical principles and one based on the legal concept of negligent liability. Each is a valid way of understanding the case, but the task they were set demands the students to apply the legal perspective. Specifically, the students need to consider whether the surgeon's withholding of a more extensive warning has had a causal or contributing effect to the damage sustained by the patient.

The two perspectives do overlap: both reference explicitly the failure to fully inform the patient about the risks of the surgery. It is correct, as Erin states in 77 and continues to maintain throughout the discussion, that the clinician has failed to obtain informed consent from Ms Chester and has therefore violated her right to be informed. However, the ethical perspective is

not sufficient to identify the causal relation that is at the core of cases of negligent liability, i.e. whether the failure to inform Ms Chester caused or causally contributed to the damage she sustained.

The interest in the discussion lies in the conceptualisations that are constructed within the two perspectives. These conceptualisations have been identified by analysing the interpretations the students give to aspects, and, more specifically, the role and relevance they assign to the aspects. The picture that emerges from that analysis is the following: Erin proposes the first conceptualisation of the case. This conceptualisation is embedded within the ethical perspective. Within this conceptualisation, the most relevant aspect of the case is the absence of adequate warning, because it violates the patient's right to information and more generally, it violates the ethical principle of autonomy. Most other aspects of the case have no relevance in this conceptualisation. Later, Erin assigns some relevance to the aspect 'aversion to surgery' by pointing out that, given Ms Chester's aversion, it is all the more important to inform her. Claire accepts Erin's perspective on the case, but is critical. She points out that since the risk was so small, informed consent was not needed. She treats the 'smallness' of the risk as the aspect which aspect that trumps Ms Chester's right to be informed.

As it has been shown, Susan constructs a different conceptualisation within the perspective of negligent liability. Susan identifies correctly the causal relation between the extent of the warning and the harm, and interprets the other aspects on the basis of this structure. This new conceptualisation assigns different roles and relevance to the aspects. For example, the 'smallness' of the risk is irrelevant within this structure. As described in detail Susan reuses and re-interprets structural and surface knowledge introduced by her peers. What can be observed in this exchange is the construction of a new (and, given the task demand, correct) conceptualisation that selectively exploits structural and surface elements of an earlier conceptualisation within a different perspective. Susan's restructuring is a genuine insight and brings with it, as insights do, a novel re-interpretation of knowledge elements.

To what degree then, is Susan's conceptualisation a co-construction? Theberge-Rafal (1996) describes co-construction as the phenomenon where utterances by different speakers represent a complete idea. Likewise, McGregor & Chi (2002) classify exchanges as evidence for co-construction if a complete idea is expressed across different speakers. This definition does not distinguish between the construction of the idea conceptually (which may or may not be joint) and the joint articulation of that idea. It is unclear from the published dialogues that these authors analyse whether the different contributors co-constructed the complete idea before or during its articulation. However it is clear that if co-construction were defined as the joint

articulation of a complete idea, then the dialogue between Susan, Claire and Erin would not count as an example of it.

Also, it is ambiguous whether the notion of idea as used by these other authors can refer to joint articulation of simply aspects of the problem and relevant concepts, or to an interpretation of those aspects. Roschelle's (1992) notion of joint construction is more precise. He defines joint construction and, by extension, collaborative learning as the mechanism by which a new conceptualisation is generated on the basis of a peers' partial conceptualisation. The phenomenon described in this case study calls for a refinement of this definition. Roschelle's definition hinges on the notion of partial conceptualisation. On the surface, Claire's conceptualisation cannot be called a partial conceptualisation of Susan's because it is embedded within a different perspective. However, whether Claire's conceptualisation is indeed partial depends on what interpretation Susan gave it. Susan interpreted Claire's contribution in terms of negligent liability, and completed this partial structure; that is, Claire's contribution becomes a partial conceptualisation because Susan interpreted it in this way. Which is exactly the mechanism within which collaborative learning occurs: one student proposes an interpretation or solution whose value as a contribution towards the correct interpretation depends on the interpretation of her peers.

The interpretation of the dialogue offered here changes the way in which collaborative learning can be viewed, and how educational dialogues can be assessed. It is believed that models of collaborative learning should allow the possibility that novel conceptualisations are constructed not only by modifying the conceptualisation that a peer reveals in the dialogue. Novel and better conceptualisations can be constructed by interpreting another peer's position that is very different. It is possible, for instance, that misunderstanding a peer's view can nevertheless be productive in terms of prompting the creation of a new and better conceptualisation. Learning, in the sense of constructing a novel and better conceptualisation, is individual but also collaborative because it reuses knowledge earlier deployed (made public) by a peer.

Chapter 10

Summary, conclusions and further work

10.1 Introduction

In this chapter, the research in this thesis is summarised and discussed, and some direction for future research is given.

The broad aims of this thesis were twofold: to characterise small-group case-centred discussions in terms of cognitive processes and learning outcomes and to propose a learning design for such practices. The path taken in this thesis follows Koschmann et al's (1996) recommendation of designing learning and learning environments: a design should be based on a model of current practices and the specification of learning goals, these latter derived from the stated aims of a practice and also from generic considerations on learning. These recommendations attempt to combine the vision of educators of what should be learned and how learning should occur with the accumulated experiences of practitioners incorporating what is practically possible. In the following section, the aims of the thesis will be restated and how the aims were achieved is described.

10.2 Summary

The aims of the thesis were stated in chapter 1. Here, these aims are revisited with a view to summarise the outcomes of the research project as a whole in the subsequent section.

Aim 1: *to increase our understanding of existing practices of case-centred small-group learning discussions*. In chapter 2, the claim is made that learning with cases is widely practiced but not well understood, and that understanding of this form of learning would improve with a model of learning. This claim rests on reviews of the case method, especially on Mumford (2005) and Burgoyne & Mumford (2001). The thesis sets out to develop such a model, to develop an analysis tool for case-centred discussions and to characterise case-centred discussions. The first aim of the thesis is hence distinguished into three sub-aims:

Aim 1.1: *to develop a framework to study cognitive processes in learning with cases*. This framework is presented in chapter 3. It is compiled from a review of the literature on the cognitive mechanisms of learning from examples and problems, and conceptualises learning with cases as the construction of knowledge structures using common cognitive processes. It also specifies what cognitive products are constructed as a result of cognitive processes operating on knowledge and information.

Aim 1.2: *to develop analysis instruments to identify cognitive processes and products in case-centred discussions*. The thesis developed an analysis scheme to identify cognitive processes in contributions (chapter 5). The scheme is modelled on common templates for dialogue coding schemes, and several aspects (e.g. unitising) and methodological criteria (especially construct validity) have been considered in devising it. An additional analysis tool identifying the topical relations between adjacent episodes (defined as a sequence of dialogue contributions focussing on the same topic) is also developed.

Aim 1.3: *to characterise descriptively and qualitatively current practices of case-centred discussions occurring within a typical educational context*. This aim is achieved in chapter 6. The chapter presents the analyses of the discussions, identifying which cognitive processes primarily occur, whether conceptual change has occurred, and which are the main relations between the topics of exchanges. The results of these analyses provide the basis for characterising learning in terms of processes and mechanisms and for presenting a qualitative characterisation of the learning outcomes (for the specific findings, see next section).

In the second part, the thesis addresses the second aim: *to propose and test a learning design.* This general aim is subdivided into 2 sub-aims:

Aim 2.1: *to propose a learning design for collaborative learning with cases that addresses some learning inefficiencies identified through the analysis of existing practices.* In chapter 7, the lack of conceptual change in the real-world discussions are argumentatively related to the learning design of these. To address this shortcoming, a learning design is proposed: it specifies the structure of the learning material and the learning task.

Aim 2.2: *to test the learning design.* In chapter 8, the learning design is validated through two studies.

10.3 General discussion

This section gives an overall and critical overview of the thesis, placing it within the main questions currently important for learning research.

Combining research on educational practices with cognitive science research

One of the conspicuous features of this thesis is it uses assumptions and findings of cognitive science research to study a current learning practice. While in the recent years the study of real-world cognition-in-practice has increased and thus an alignment with education research – that focuses typically more on how learning occurs in the real world – is more viable, the study of learning can be said to be still divided between cognitive science and education. One of the core problems with integrating cognitive science and education is, first, the use of models based on a normative account of learning and problem solving (i.e. what would be good problem solving, what knowledge structures *should* be acquired) and second, that much cognitive science in the past relied on a basic assumption on the mind being a disembodied 'engine'. As some research has shown, however, laboratory-based findings do not reflect real-world cognitive performances. For example, Lave (1988) showed that the performance of people on typical mathematics examples is far below the arithmetic performance of the same people when they shop in a supermarket.

The thesis' use of real-world data fits into the trend developed as a result of the criticisms levelled at proponents of 'disembodied' cognition. However, developing a framework of learning from cases by using laboratory research and then using it to interpret learning may be seen as contradicting the call for research on learning as is occurs in the real world. This criticism would be only partially valid. Indeed, normative models (such as the one developed in chapter 3) can be used in real world research to show how these models account for people's learning, but also how it differs. In the characterisation of learning offered in chapter 6, both these questions are answered: the chapter shows that learning phenomena predicted by the

model do occur (relating concepts, relating cases, learning about the conditions of applicability of concepts), describes phenomena predicted that do occur but not in the form predicted (analogies), and also describes other phenomena that are not accounted for in the model (generalising from the case to other generic issues relevant for cases of medical ethics, formulating general conditions of applicability of concepts). The thesis does hence satisfy the demand to give a theoretical account of learning phenomena while also being of high ecological validity.

The conception of learning as structuring

Within the research community studying educational practices, including the CSCL community, the conception of learning as structuring is contrary to current orthodoxy. While one can be firm on the view that abstracting a structure is a common and valuable form of learning, the criticisms advanced towards the concept of transfer (Lave, 1988) decreases an evaluation of learning in terms of structuring. The problem is not that structuring does not occur or is epiphenomenal, but rather than the knowledge structures acquired from one example are not helpful in solving isomorphic problems. Indeed, there is consensus among researchers – including some working within a traditional cognitive science paradigm – that the use of the acquired abstract knowledge requires practice[15]. Lave (1988) put the effect of practice at the centre of the conceptualisation of learning, rather than seeing it as a necessary but secondary issue, a conception that is valid also outside her more general view of learning as socialisation. In essence, Lave's answer to the question why transfer of knowledge across isomorphic problems fails is not to investigate the conditions under which that knowledge would be retrieved and used (such as, for example, the MAC/FAC model, Forbus, Gentner & Law, 1994), but rather to question the underlying epistemology of distinguishing surface from structural knowledge for modelling learning. The problem of learning is hence not a problem of learning how to apply general knowledge, but of practice, this notion conceptualised outside the traditional epistemology. Learning, in this sense, is exclusively the incremental, progressive acquisition of knowledge, knowledge being 'knowing how to interact', 'knowledge what to do', 'knowing how to use artefacts'. The social environment is a central component of learning because people would learn while being guided by a more experienced practitioner (whether it is a butcher, tailor or researcher). This conception has been extended to the notion of cognitive

[15] It is possible that there are two meanings of practice. Anderson & Schunn (2000) concede, in their discussion on the role of cognitive science research, and especially the ACT-R model, in education, that practice is essential for learning. However, it appears that they intend practice to be 'continuously doing things' (and doing these things as specified by ACT-R), rather than the complex interaction between the learner, the environment and the more experienced practitioner.

apprenticeship Brown, Collins & Duguid (1989) who argue that also thinking and reasoning is learned by being guided by more expert thinkers.

There is still a wide gap between the conception of learning as structuring and the conception of learning as cognitive apprenticeship, not to mention the conception of learning as socialisation (acquiring a professional identity), and the gap can only be closed once the question is answered about what kind of knowledge is acquired when people learn. The thesis does not give a clear answer to this question either. However, its assumptions and the approach position the research in a way that it may contribute to the answer. Specifically, the research observes how learning occurs in the real world, but also relies on the traditional knowledge representation framework to describe learning. That is, it observes a learning practice and describes the effect of that practice on people's conceptual structure and knowledge structures. The situation it describes is hence not an artificial reproduction of an learning situation that characterised much of past cognitive science research on learning, and hence the findings con contribute to the understanding of the effect of practice (intended as 'doing' rather than in Lave's sense) on learning.

The representativeness of the studied current practice

In light of the findings on learning in the discussions on the euthanasia cases, the claim about the representativeness of the discussions for case-centred teaching practices must be reduced. Indeed, a simple argument can be made that if the learning outcomes of such practices were represented by the findings (chapter 6), the case method would have been abandoned by the educational community. Clearly, the research focused on only about 2 hours of discussions, rather than on an entire semester or even year-long course. The gradual, slow form of learning observed may however by typical for the method, and it is possible that the continuous engagement with cases over a long time would result in substantial learning gains that could not be observed in the short time. The representativeness of the analyzed practice relies hence structural similarities to other case-centred practices: the material used, the tasks given, the group composition and the overall role of the discussions as opportunities to apply conceptual knowledge to concrete real-world situations.

The limits of the approach: additional factors in learning and learning design

Though the idea of learning design adopted in the thesis is similar to the notion of a 'learning ecology' (cf. Cobb et al, 2003), the design focuses especially on the appropriate specification of the material and the task. This is certainly a quite narrow focus, but epistemologically highly

valuable because relatively unusual (although some research on analogical learning does also focus on the effect of the material, e.g. stories). The investigation of learning should incorporate many other aspects of a learning environment, including to a higher degree the learners' preconceptions (that in this research were only assumed rather than assessed). The learners' performance on the cases of medical law demonstrates that the engineering of a specific form of learning by adopting the approach to design of this thesis is indeed limited. Though some learning occurred, the performance was less successful than expected. The analysis cannot, at this point, identify why the students did not pose the core question in some cases, because it appears that factors outside the analysis framework (such as the students' sympathy for the patient, or the students' inclination to 'solve' the case rather than to explain it) will need to be taken into account. However, rather than incorporating aspects into the analysis, it would be better to continue to investigate the effect of the material and the task, and to manipulate these factors. The performance in study 3 can be taken as evidence that indeed this analysis and design focus can be proficient.

10.4 Findings and research contributions

The contributions of this thesis can be considered at several levels, from concrete findings about current case-based learning practices, to insights into how to design learning, to more general insights into the nature of collaborative learning with cases.

10.4.1 Main finding

1.

Increasing our understanding of current case-centred collaborative practices.

The thesis contributes to our knowledge about what students are learning in current case-centred collaborative practice. The following picture emerges: current practices do promote valuable learning gains especially as concerns the acquisition of knowledge about the use of known concepts to interpret real-world situations. The preponderance of the processes of verifying whether a known concept applies to the situation, and also the occasional explicit formulation of more general conditions of applicability of concepts, attest to this. More generally, the students use their conceptual knowledge and check with care whether it is useful in interpreting the case. By doing so they reinforce their existing conceptual system, a system of lay ethics concepts. That system becomes bound to the specific situation discussed, from which it is concluded that the students acquire valuable episodic knowledge, usable for future isomorphic situations.

Further, remindings of structurally similar cases occurs quite frequently, by which students acquire a small knowledge base of cases, also reusable for future interpretations. It is common that, when such remindings occur, the similarity between the cases is identified, and features so identified are highlighted. This form of learning is described as 'acquiring a domain-specific vocabulary' consisting of defining features of situations. This vocabulary is useful for encoding other situations. It has also been observed that the students discuss issues outside the domain of ethics (e.g. the role and responsibilities of the players involved) that are nevertheless important for future practicing physicians.

However, overall, learning is characterised as conservative. This characterisation derives from the fact that the analysis did not reveal conceptual change, intended as the radical restructuring of an external object (the case) and maybe accompanied by an internal restructuring of conceptual knowledge. Nor was it evident that the students have acquired a deeper, better and more expert-like understanding of the core ethic principles.

10.4.2 Research contributions

2.

A conceptualisation of learning with cases from a cognitive perspective.

This thesis proposed to increase our understanding on learning with cases by adopting a cognitive science perspective. Chapter 5 describes a framework that is a novel conceptualisation of this form of learning. The framework is to be considered a stand-alone contribution of the thesis specifying which processes occur when people learn with cases, what knowledge they use when doing so, and what knowledge they construct.

3.

A set of generic guidelines for designing collaborative learning with cases.

The thesis contributes to the current interest of the educational community to design learning. General guidelines for a learning design for collaborative learning with cases can now be adduced that rely on a set of specified learning goals but also take into account the shortcomings observed in current practices.

The learning design proposes to implement the following design components:

- Including an expert opinion and explanation. This information should challenge the learners to produce a new and better conceptualisation.

- assigning an explanation task. The combination of explanation task and expert explanation reproduces a situation where people fail to solve a problem, try to find an explanation for their failure but have expert knowledge available that helps them to identify gaps in their knowledge. Expert explanations also function as a model for the students to emulate.
- one of the features found favourable of the original design, the use of multiple cases, should be extended to include more isomorphic cases, to encourage learning from mapping and from abstracting their common structure.

4.

A prototype coding scheme to identify cognitive processes in contributions to be used to characterise collaborative learning with cases in real-world settings.

Chapter 5 presents a coding scheme to identify the processing of knowledge and information in students' utterances. The proposal to interpret the learners' contributions as cognitive processes is based on the assumption that in group learning situations, people construct jointly a 'virtual object' (the interpretation and conceptualisation of the case) by relying on cognitive processes. The scheme is successfully applied to real-world data collected for this thesis. That is, the scheme's construct validity is sufficient to justify further use on different data sets. However, a more extended use of the analysis scheme would require ascertaining other methodological criteria, such as reliability and objectivity. As it is presented in chapter 5, the scheme is specified in a way to be usable by other researchers, thus making it possible that the further methodological criteria may be ascertained.

5.

Showing the viability of the approach to identify the processing of information in dialogues

One important assumption of this thesis is that collaborative learning can be studied by identifying cognitive processes in discussions. The research presented in this thesis allows insights into the feasibility and viability of this assumption. Construct validity of the coding scheme relates directly to the validity of the assumption. That is, the coding scheme was able to capture the phenomena it was designed to capture. Thus, to interpret discussions in terms of cognitive processes appears to be a viable approach to address questions on collaborative learning.

6.

Showing the viability of the approach to infer what cognitive structures are constructed from externalised cognitive processes.

One of the substantive research outputs is a qualitative description of the learning outcomes of small-group discussions. This output rests on the notion of 'virtual object' that the learners jointly construct. This entails an analytical focus on the content of dialogues, rather than only on the structure of interactions.

Related to the focus on what learners talk about is the interest in learners' existing knowledge structures and its use in modelling dialogues. Specifically, part of the analysis relies on the assumption that the learners retrieve knowledge and deploy it into the discussion because of simple remindings and prompts. The assumption is made that relations between knowledge items are responsible for the introduction of knowledge into the discussion. The theoretical status of this assumption within collaborative learning research has not been discussed in the thesis, and the assumption may be orthogonal to the more common view that it is argumentation structures that direct a discussion. The analysis based on this assumption is relatively small, and is considered as a first attempt of modelling dialogues from this perspective. However, it was possible to classify most of the data according to the simple coding scheme deriving from the assumption and a simple model of memory retrieval.

7.

A conceptualisation of collaborative learning as the reuse of externally available structural knowledge.

Chapter 9 presents a conceptualisation of a central mechanism of collaborative learning: the reuse of structural and surface knowledge. Specifically, an analysis of an exchange is presented that illustrates how one learner reuses structural knowledge introduced by another learner as part of one conceptualisation of the case, to construct a different conceptualisation. This novel conceptualisation is also the correct one, and represents a significant conceptual change. The fundamental aspect of the reused knowledge is that it is structural, i.e. it results from a conceptualisation produced by a learner, rather than being part of the case description. The analysis illustrates that some of the thesis' underlying assumptions and their combination are epistemologically valid, and are able to shed light on some phenomena of collaborative learning.

8.

An extension of models of analogical learning: the phenomena of re-analysis and backwards transfer.

The small variation in the design proposal, namely to promote the reuse of solved cases to solve current ones, permitted insight into a possible additional mechanism of learning from reuse. Specifically, the analysis of a single group discussion on two software engineering problems

(that were to be mapped) showed that, while the second problem was being solved by reusing an earlier problem, also the understanding of the earlier solved problem changed. This phenomenon is interpreted as demonstrating that the analysis (done in order to gain knowledge about how to solve the current problem) of the earlier problem is influenced by the demands of the current problem, and that it undergoes a demand-driven re-conceptualisation. This phenomenon is called learning from re-analysis: information contained in the earlier problem is re-interpreted by analysing it, and that analysis is driven by the conceptualisation of the current case. Some knowledge is hence transferred from the target to the base, a phenomenon called backward transfer.

10.5 Future work

This section on further work is subdivided into work that could provide improvements furthering the specific aims of the thesis, and work that targets the general research approach and the assumptions. This distinction is made because the assumptions and the approach of this thesis are common in learning research, but more theoretical research would be needed in light of the thesis' contributions.

Further development of the framework and the coding scheme

The core characteristic of the model is that it is analytical rather than empirical, i.e. it is to be seen as a framework rather than a descriptive account of empirical data. Though the frequency of utterances that could be classified according to the coding categories is sufficient to support a characterisation of learning, the model should be further developed by taking into account possible learning processes evident in the data but not covered by the framework. The framework has produced certainly a foundation upon which to base a data-driven refinement of the coding scheme. For example, the distinction between three kinds of knowledge (conceptual, episodic and factual) is to be maintained as the basis for further refinement.

Other cases, other domains

A further validation of the framework's ability to characterise collaborative learning with cases would require analysing small-group discussions on cases that are of different size and are from other domains. The coding scheme is especially apt in capturing learning of relational knowledge from studying cases consisting of several more events, players, actions, etc. than the cases analysed for this thesis consist of. Specifically, learners acquire knowledge about how events, people, actions, etc. interact by, for example, analysing how an action to carry out a

certain plan had intended and unintended consequences. Knowledge about these interrelations, probably a form of dynamic mental models, is often quite simple and of qualitative nature, but powerful enough to guide problem solving and interpretation (cf. Forbus & Gentner, 1986). Cases of more complexity are often found in business and management education. The framework and the analysis scheme would probably be able to capture learning of this kind of knowledge, a form of learning that places less emphasis on the refinement of conceptual knowledge than the kind observed in the discussions analysed for this thesis. Clearly, it may be necessary to refine the framework and the coding scheme, but, again, the foundations for capturing collaborative learning with cases of other domains are already present.

Analysis of the environment including learning resources

The approach to consider knowledge in the joint problem space as external and reusable objects is derived from a similar assumption that has pervaded research within the paradigm of distributed cognition. While most of this research focuses on concrete objects (such as computer interfaces, learning artefacts, etc.), this thesis has focussed exclusively on knowledge. To increase our understanding of how people learn with cases the notion of environment should include learning artefacts and their use by the students. For example, in the face-to-face discussions the learning resources are less readily available than in the computer-based environment, and lack of ready access may have affected learning. This focus would shift the analysis from the question on what is learned further towards the question on whether the conditions for learning were sufficiently present to support learning. However, it may be possible, with the additional analysis, to identify relations between the condition of learning and the acquisition of knowledge

Elaborating and evidencing the hypothesis of reuse

The analysis of the exchange showing the reuse of structural knowledge (chapter 9) is an illustration of a possible mechanism of collaborative learning, and of the approach to be taken to evidence it. A conspicuous feature of the exchange is that it is an argumentation (in a broad sense): the students do not agree on the conceptualisation and argue about which one the correct one is. The exchange may be used as an example where argumentation and conceptual change overlap. More in general, the analysis points to a possible relation between a dialogue structure and the joint construction of knowledge.

Though the exchange has been discussed with reference to a current model of collaborative learning, more findings on the role of arguments in learning, intended as knowledge

construction and knowledge acquisition, are necessary. This is necessary because normally the effect of arguments on learning intended as the acquisition of knowledge structures is underspecified.

The most important future work following the hypothesis of reuse is however empirical: either through analyses of other dialogues or through a controlled study, the phenomenon needs to be evidenced more clearly and consistently. The empirical research could either target discussions where argumentations occurred spontaneously (e.g. because learners had different viewpoints) or set up the conditions that promote different viewpoints in need to be discussed.

The importance of the phenomenon of reuse should be seen within some core questions of collaborative learning: how do people converge on a common interpretation, is convergence, as opposed to conflict, the core condition for learning (cf. Roschelle, 1992), and how to conceptualise the role of different viewpoints in collaborative learning. Schwarz' (1995) studies, showing that arguments lead to the collaborative solution of problems even if the members possess incorrect knowledge, is especially important here: it may be an indication that successful collaborative learning results from the building-up of a joint construction consisting of individual knowledge items. Reuse of de-contextualised knowledge items may be a possible mechanism, though the question about when collaboration is successful and when not (assumed that reuse occurs in both cases) remains unanswered.

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Appendices

Appendix 1

Example of a case used for teaching

The following is a case used in undergraduate medical education to teach Anatomy & Physiology (retrieved from **http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm**). The case illustrates the typical case structure: it consists of a short story, diagnostic data and specific questions. Cases may be, however, up to 100 pages long (especially business and management cases).

A case of Iron Deficiency Anemia

Dolores Welborn is a 28-year-old attorney living in Portland, Oregon. Dolores is in the second trimester of pregnancy with her first child, and though her pregnancy had been progressing normally, recently she has noticed that she tires very easily and is short of breath from even the slightest exertion. She also has experienced periods of light-headedness, though not to the point of fainting. Other changes she has noticed are cramping in her legs, a desire to crunch on ice, and the fact that her tongue is sore. She doubts that all of these symptoms are related to one another, but she is concerned, and she makes an appointment to see her physician.

Upon examining Dolores, her physician finds that she has tachycardia, pale gums and nail beds, and her tongue is swollen. Given her history and the findings on her physical exam, the physician suspects that Dolores is anemic and orders a sample of her blood for examination. The results are shown below:

Table 1. Blood Sample Results	
Red Blood Cell Count	3.5 million/mm^3
Hemoglobin (Hb)	7 g/dl
Hematocrit (Hct)	30%
Serum Iron	low
Mean Corpuscular Volume (MCV)	low
Mean Corpuscular Hb Concentration (MCHC)	low
Total Iron Binding Capacity in the Blood (TIBC)	high

A diagnosis of anemia due to iron deficiency is made and oral iron supplements prescribed. Dolores' symptoms are eliminated within a couple of weeks and the remainder of her pregnancy progresses without difficulty.

Questions:

- Describe the structure of a molecule of hemoglobin and explain the role played by iron in the transport of oxygen.
- How is iron stored and transported in the body?
- What is Iron Deficiency Anemia (IDA) and how frequently does it occur?
- What are the most common causes of IDA?
- Why are women more prone to IDA than men?
- What are the red blood cell indices, and what tests are diagnostic for IDA?
- How is IDA treated and prevented?

Appendix 2

The right to die: the case of "Miss B".

"Miss B" (her identity remains hidden) was a 43 year old local authority social worker, with degrees in social sciences and public policy administration. She was unmarried and childless, but with a close circle of friends, and a godchild.

In August 1999 she was warned by doctors that the blood vessels in her spinal column were "malformed", placing her at risk. As a result, she wrote an advance directive instructing doctors not to treat her - even to save her life - if she was left suffering from a life-threatening condition, in a coma, or mentally impaired.

In early 2001, symptoms emerged which suggested that the problem was getting worse. Miss B suffered weakening of the left side of her body and numbness in her legs. Shortly afterwards, the malformed blood vessels ruptured, causing a massive bleed, and leaving her paralysed from the neck down. She was unable to breathe unaided, and required constant intensive care, with a ventilator, to keep her alive.

She was given an operation, as a result of which she was able to move her head and speak. At this point she asked for the ventilator to be switched off. The doctors wanted her to move to a rehabilitation programme.

Two independent psychiatrists were called in to assess her mental condition, and to find out whether she was capable of making such a radical decision. Initially, they agreed that she was indeed capable, but a few days later reversed that decision - prescribing antidepressants instead. Miss B began a legal action to bring the ventilation to an end.

In her evidence, Miss B – who had found a great deal of information on the internet, and had communicated with other people in similar situations – said she had rejected the programme to wean her off the ventilator because all her enquiries into likely outcomes showed that there was

no chance of recovery, and that what would happen during the process and afterwards was totally unacceptable to her.

In her judgment, Dame Elizabeth Butler-Sloss ruled that Miss B had the "necessary mental capacity" to refuse treatment, even if that meant her death, and that she had the right to be transferred to another hospital which would treat her according to her wishes "and permit her life to end peacefully and with dignity".

She also awarded Miss B nominal £100 damages for "trespass": the unwanted medical treatment involving the ventilator.

Appendix 3

The right to die: the case of Diane Pretty

Mrs Pretty gave this account of her situation on her website: www.justice4diane.org.uk

I am only 43 years old. I desperately want a doctor to help me to die. Motor neurone disease has left my mind as sharp as ever, but it has gradually destroyed my muscles, making it hard for me to communicate with my family. It has left me in a wheelchair, catheterised and fed through a tube. I have fought against the disease for the last 2 years and had every possible medical treatment. I am fully aware of what the future holds and have decided to refuse artificial ventilation. Rather than die by choking or suffocation, I want a doctor to help me die when I am no longer able to communicate with my family and friends. I have discussed this with my husband of 25 years, Brian who has come to terms with what I want and respects my decision. He says that losing me will be devastating for him and our two children but he would be pleased to know I had had the good death I want. I want to have a quick death without suffering, at home surrounded by my family so that I can say good-bye to them. If I were physically able I could take my own life. That's not illegal. But because of the terrible nature of my illness I cannot take my own life - to carry out my wish I will need assistance. Should a doctor give me the assistance I need, he or she will be guilty of a crime that carries a lengthy prison sentence. As the law stands it makes no sense. The law needs changing so that I, and people like me, can choose how and when we die and not be forced to endure untold suffering for no reason.

BBC News Online gave this account of her campaign:

November 1999: Diane Pretty is diagnosed with motor neurone disease, a degenerative condition which has left her completely dependant on her family. The disease has no impact on her intellect, but within four months it confines her to a wheelchair.

June 2000: Mr Pretty writes to Tony Blair pleading for a change in the law. He says his wife wants him to help her end her life.

August 2001: Mrs Pretty asks to the Director of Public Prosecutions, David Calvert Smith QC to grant her husband immunity from prosecution should he help her to commit suicide. The DPP acknowledges that Mrs Pretty and her family are experiencing "terrible suffering" - but he refuses to grant immunity.

August 31, 2001: A High Court Judge grants Mrs Pretty the right to challenge the DPP's decision through the courts. She claims it represents an infringement of her human rights.

October 18, 2001: Three High Court judges, headed by Lord Justice Tuckey, reject Mrs Pretty's appeal. They conclude that the UK is not ready to sanction the idea of assisted suicide.

November 29, 2001: The Law Lords, headed by Lord Bingham, confirm the decision of the High Court.

March 19, 2002: A 90 minute hearing in the European Court in front of seven Human Rights judges. Mr and Mrs Pretty travel by ambulance for 12 hours to attend.

April 29, 2002: Human Rights judges in Strasbourg rejected the appeal.

May 3, 2002: Mrs Pretty is admitted to a hospice. She develops a chest infection and breathing difficulties.

May 11, 2002: Diane Pretty dies at a hospice near her home.

Mr. Pretty gave this account of her death:

On Thursday 2 May, Diane asked me to call the doctor as she was having trouble with her breathing. She had no chest infection and her airways were clear. The next day she went into the hospice and started having breathing problems again. The doctors and nurses managed to get her stable for a few days but she was still in pain. The staff were wonderful at their job and there was always someone there with her.

They had trouble getting her comfortable and pain-free until Thursday evening, after which she started to slip into a coma-like state and eventually died. Diane had to go through the one thing she had foreseen and was afraid of - and there was nothing I could do to help.

Appendix 4

The discussion of group 1 on the euthanasia cases.

The figures show the transcripts and the coding of processes and episodes (including the focus of an episode and its topical relation to the focus of the previous episode).

Notation on coding episodes (for the notation of the transcripts, see figure 6, page 98):

- '[' and ']' (in column 4) mark the start and end of an episode, respectively. When a new episode is opened, it is assigned a sequential number
- '[#]' denotes a singleton counted as an episode
- '([])' denotes a singleton not counted as an episode (its content has no bearing on the subsequent contributions)

#	contri-butor	utterance	episode #	episode focus	relation with previous episode	process
1	I	that was not her, but that could be like from, ... you know, maybe the layperson, or the UK rights of ... aah, high court judges. Lord justice ...., you know, suicide is wrong in all cases, therefore, you know, we understand that this is horrible, but it's still wrong, I mean that's not my personal belief, but that's my catholic belief ... it's wrong in all cases. I'm catholic, and so, I'm sorry you're suffering, but it's wrong in all cases.	[1]	society's stance on euthanasia		
2	E	so how did she, how did she, ... she's {having? on her?} ventilation, which meant that (looks at sheet) she's going to {trick?} so she wanted additional help, so what did she want, an injection, or ...?	[2	autonomy	semantic (contrasting to society's stance)	
3	C	I think she wanted an injection.				
4	E	**				
5	C	(approving) mmh				
6		(all three look into the hand-outs)				
7	E	she wanted a treatment to be able to do it.				
8		(4sec looking at sheets)	]			
9	E	and maybe it's quite honourable, I'm not sure {if?} even got to a point * he could have just put sleeping pills in her drink. ** would ever have done *** and if they hadn't gone through all of this then * {talking/token of/to?} died the way she'd wanted to.	[3	beneficence	conceptual supporting	
10	C	so, she shouldn't have asked * if * husband				
11	E	if they wouldn't have gone to court in the first place				
12	I	they could have done it, yeah ...				
13	E	... they would have never found out {that she was about to do it?} because if they would have found out he [the husband?] would have gone to {prison?}				
14	I	(approvingly) mmh				
15	E	maybe he was prepared to do it				
16	C	*** because {he?} has kids				
17	I	(interrupting, thus unrelated to what C says) that could have been part of his value judgement as well				
18	C	(continuing) no, {but?} {doctor? husband?} * has kids so if he {ever?} {got?} found out				
19	E	(approvingly) mmh				
20		(2 sec pause)				

#	contributor	messages		episode focus	relation with previous episode	process
21	E	so, {won't? will?} the kids do it ... (theatrical, jokingly) the five year old * drugged me the drink	]			
22	I	(looking up from sheet and writing) so the general fact * I think {across? [agrees?]} everybody is that ... motor neuron disease will eventually, ... is a debilitating degenerative disease that's lethal, ... fatal (writing)	[4	task	other (back to task)	
23	E	... and she wasn't gonna recover from it...	([])			relating aspect and concept (beneficence)
24	I	yeah				
25		(all write 'debilitating degenerative fatal disease)				
26	I	and the particular fact about her is that she has that disease and that she's not gonna recover from it				
27	C	and she's probably ..., she's gonna die from it ...				
28	E	and she struggling with it already, it's not that is it just like suddenly, it's like ...				
29	C	{but as a matter of fact?} she isn't suffering ...				
30	E	she isn't suffering, and she's received medical treatment already to trying to help her {cope with it?}				
31	I	(while writing) Mrs. Pretty has suffered from this disease and has already received treatment				
32	C	is it treatment?				
33	E	ahmm, I think that's what she said (looks at sheet)				
34	C	I think it's more {like? likely?}				
35	E	(pointing to sheet and reading) "medical treatment, I've had every possible medical treatment"				
36		(all writing: "and received every possible ...")				
37	E	and the general facts and the particular facts are the same ...				
38	I	(interrupting) across the board, isn't it				
39	E	... no matter who ...	]			
40	I	yeah. ..... [seems like new idea coming] so, ... legally, the values are,... ... that the UK is not ready to sanction the idea of assisted suicide	[5	task	other	

#	contributor	messages	episode	episode focus	relation with previous episode	process
41	E	{so?} legally, when she first went to court...				
42	I	yeah				
43	E	... she had to go to court because {that's?} *. ..... because it was illegal to get her husband to {have that?}				
44	I	right, so (as if citing) assisted suicide is illegal, therefore (starts writing, but is interrupted)				
45	C	particular fact, **				
46	I	(not listening) this is ...				
47	C	{it is?}particular fact				
48	I	it would be ... (holds on) (uncertain) yeah				
49	C	{being not?} legal				
50	E	(disapprovingly) hmm [no, no] it's a general fact				
51	I	(nodding) it's a general fact				
52	E	(as if citing) ** is illegal in the UK (all start to write)				
53		(5sec writing)				
54	I	so carrying on from that, particular fact would be ...				
55	C	the DPP [?] **				
56	I	(interrupts) [seems not to follow on from what C said] ..... the people who would deliver euthanasia to Mrs. Pretty are acting illegally therefore their value judgement is it is illegal in all senses to ... no				
57	C	{that?} {would be?} ** general fact *				
58	E	well, if we are saying that euthanasia is illegal ... general fact, particular fact therefore her husband can't help her kill herself				
59	C	yeah				
60	I	(approvingly) mmh				
61	C	yeah, our value judgment would then be ...				
62		(all three start to write, 4sec ca.) [9:10]				
63	E	can't assist her				
64		(...)				
65	I	{hospital?} doctors can't assist				
66	E	(approvingly) hmm				
67	I	and then the value {at? that?} the legal system is ...				
68	C	the value is that you have to preserve the life {from? for?} the {lecture?}				
69	E	yeah, so that's {where} {everything} * {ok?}				
70		(all three write)				
71	I	(as if citing) laws are there ...				
72	C	to protect life				

#	contributor	message	episode	episode focus	relation with previous episode	process
75	I	or is that's general				
76	E	I don't know whether that's ...				
77	C	that's probably not {a?} value	]			
78	E	the value in relation to this case is that ... ahmm ... doctors are supposed to preserve the life of patients at any cost because ..... yeah	[6	beneficence	semantic-associative (law-ethics)	
79	I	doctors must operate under legal frameworks ...				
80	C	so *** are we in the shoes of the husband or the general public?	([])			
81	E	(dismisses question waving hand)				
82	C	**	]			
83	I	[not related to what C said] [C and E often interject approving 'yeah'] I think a value would be that doctors need operate under legal frameworks, if you're looking at it from a legal ... if you're going from a general fact (citing from what she wrote) that euthanasia is illegal, particular fact therefore (addressing again the others) doctors and husband can't assist, and the value judgement would be, well they need to ... you know that's my opinion that they have to operate within the law	[7	nonmaleficiance	conceptual contrasting	
84	E	yeah [10:27]				
85	C	ok	]			
86	E	because in this case they were operating within the law and, say, they wanted to preserve life, but the weren't... but they weren't ... really ... they weren't ... they weren't really relieving suffering were they? ... which some people would argue {it would be?} ** preserve life. Some people they * doctors *** relieve suffering * preserve life, but {when?} they are suffering more {I mean?}then they should be able ** that's when ** (talking while looking at fingernails, not very convinced, others not really listening)	[8	'do good' and 'preserve life'	other	relating concepts (both meaning of beneficence)
87		(10sec pause)				
88	C	** {that's what} {within the law?} **				
89	E	yeah	]			
90	C	* and preserve life **	[9	beneficence	other	
91	E	isn't it just a general fact that doctors must work within the law?				
92	C	no, {I think?} that's a doctor's value				
93	E	Oh, yeah, yeah				
94	I	it is, yeah				
95		(2 writing)	]			

#	contributor	message	episode	episode focus	relation with previous episode	process
96	C	on the other hand, like {the? her?} husband {value?} {would be like?} you should let my wife, ... it's her life, so she has to decide whether she wants to die	[10	autonomy	conceptual supporting	relating aspect and concept (autonomy)
97	E	* value *				
98	I	his value would be ... prevent suffering, ... as you (pointing to E) were saying about		(beneficence)		
99	E	yeah				
100	I	what were you saying ...	]			
101	E	that the doctors in this case were more ..... aahm ... concerned with preserving her life than relieving her suffering...	[11	beneficence and nonmaleficiance	other	relating concepts (beneficence and nonmaleficiance)
102	I	(tentatively approvingly) mmm				
103	E	because ... by helping her, giving her injection or whatever it would have relived her suffering but {wouldn't?} doing it because it wouldn't be right because it would have gone against preserving her life, so it depends on who's judgement they {w?}* [12:28]	]			
104	I	so the doc..., if we were looking at the doctors (looks at sheet) as a general fact could be the same... and particular fact is ... aahm	[12	nonmaleficiance	other	
105	C	everything {is the same?} except for the...				
106	I	(interrupting, not listening, attempting to write) ... every possible ..... but the doctor's value would be that ... ... we need to preserve life				
107	E	in this case I don't even know if it was ... the doctors' values that meant that ... she can have it in the end, it was more the court's value, wasn't it. ... 'cause I'm sure there were doctors who were saying, look I'll do it but it needs to be legal				
108	C + I	yeah				
109	E	so I don't know whether they actually turned on the doctors' value judgment at the end because ...				
110	I	(interrupting, looking at sheet) yeah, it doesn't mention actually anything about the doctors				
111	E	yeah, I mean, it wasn't the case that she wasn't able to find a doctor who would do it	]			
112	I	so what about her?	[13	autonomy	conceptual contrasting	
113	C	yeah, I think she just wants to end her suffering...				relating aspect and concept (beneficence)

#	contributor	message	episode	episode focus	relation with previous episode	process
114	E + I	yeah, yeah				
115	C	... that's my life, I should be allowed to end my suffering				relating aspect and concept (beneficence)
116	E + I	yeah [13:30]				
117		(all three writing, 20sec)				
118	I	and the husband ...				
119	E	(interrupting) was that her value judgement... that, ... that she should be allowed to end her life?				
120	I	it's, ... it's my life, I ..... can't do it myself but yet suicide isn't ..... if I can do it myself it's not illegal, so therefore I should be able to, ... be able to, ... have someone assisting me, .. because I would do it anyway if I could	]			
121	E	** I can't believe that there would be many people who disagree with it ..... unless they very strong religious beliefs [14:20] but, but, ... the decision on the end, I do bet that the people at the end didn't allow her to do it ... they didn't turn on their religious beliefs, but they turned on the fact that the whole British law would be changed.	[14]	universalisibility	conceptual contrasting	relating concepts (beneficence and universalisibility)
122	I	yeah, ... there was a huge case in Canada a few years ago, were a father assisted his daughter, she was really very disabled ... and no quality of life [C and E seem to know the case] and he just suffocated her, and I think he got 12 years manslaughter.	[15	beneficence	conceptual contrasting	analogy ('quality of life')
123	E	she actually {left a note writing?}				relating aspect and concept (autonomy)
124	I	no, she was actually 12 years old and very disabled	]			relating aspect and concept (beneficence)
125	E	{there are cases where the doctors are going to push the button?} (...)	[16	universalisibility	conceptual contracting	
126	I	it is difficult, you can see where it is going to be very blurred, if somebody, you know, ... who judges what is quality of life				relating aspect and concept (universalisibility)
127	C	***				

#	contributor	message	episode	episode focus	relation with previous episode	process
128	E	(talking at the same time) but in this case (pointing to sheet) she was sick				relating cases ('sick')
129	I	she was, but you know in this case I think if they said that this is legal then it could potentially open up a lot of, ... a lot of blur kind of, a lot of grey areas				
130	E	...where to draw the line...				
131	I	exactly				
132	E	... someone has to be able to say and someone has to be able to write...				relating aspect and concepts (universalisibility)
133	I	yeah, and ... usually saying ..... but it's you know, they say, yes, people can do this basically, then suddenly husbands killing their wives all the time (laughing) saying, you know she wanted it				
134	E	(jokingly) she had no quality of life ...				
135	I	yeah (laughing) ... [15:55]				
136		(30sec jokes)	]			
137	I	(while writing, to herself) it's my life, I want to end my suffering...	[17	autonomy	conceptual contrasting	relating aspect and concept (autonomy)
138		(15sec pause)				
139	I	actually * particular fact could be that, if she had .....if she could she would commit suicide				relating aspect and concept (autonomy)
140	C + E	yeah				
141	I	(writes:'if she could...')				
142		(5sec pause)				
143	I	and then to saying, well, ... and therefore I should be able to commit suicide...with assistance, ...because I would do it anyway [17:16]				
144	E	yeah				
145		(3sec pause)	]			
146	E	if they said no to this case, they ** couldn't say yes to any case ...	[18]	universalisibility	conceptual contrasting	
147	I	exactly, ... it's really sad, isn't it	[19	cultural environment	Semantic-associative (the impossibility to solve the cases ("it's sad"))	
148		(look through sheet, read about the story)				
149	E	I can imagine he [the husband] felt so helpless				

#	contributor	message	episode	episode focus	relation with previous episode	process
150		(3sec pause)				
151	I	who's that doctor in the US that does euthanasia, ... that's not Shipman obviously, ... Doctor Kervokian ...**... I don't know,				
152	C	doctor death				
153	I	yes, doctor death, basically he does and assists people who wanna die[18:30]				
154	E	but not like Shipman				
155	I	no, no, ... he makes no secret of it				
156		(...)				
157	I	I would hate [to be in a situation like Mrs. Pretty], where I am a burden to my family, where I can't take care of myself, where I can't communicate, ... I would rather just				relating aspects and concepts (beneficence, nonmaleficiance)
158	E	{it must be miserable?} {we are not yet so advanced like?} Holland... but because they are so educated				
159		(talk about Holland, liberal policies and resulting practices/services not related to euthanasia) [20:18]	]			
160	I	(takes sheet) should we look at Mrs. B then?	[20	task	other	
		(ask Peta, then look though sheets				
		[22:03]				
161	I	I mean, this is pretty * basically, she is refusing treatment, ... see, refusing treatment * to be actually killed is very different, isn't it.	]			relating cases (active versus passive euthanasia)
162	E	** doctors are so, ... * wanting to make anyone live no matter how {ill they are?} I mean, she can't actually move, ... from the neck down, never will be able to move, the doctor wanted to move her to a rehabilitation program, why?	[21	beneficence	semantic-associative	
163	I	I mean, it's all about someone's quality of life, she's never said I wanted to die...				relating aspect and concept (beneficence)
164	E	yeah				
165	I	... she just said, I wanted my ventilator turned off				relating aspect and concept (autonomy)
166	C	**** wanted to be taken off the ventilator				
167	E	and if she came off the ventilator, she would die [22:52]				
168	I	yeah				
169		(3sec pause)	]			
170	I	I mean, they prescribed her anti-depressant, well of course she's depressed	[22	establishment	other	relating aspects
171	E	(jokingly patting on I's shoulder, imitating a doctor) don't worry...				
172	I	(jokingly, imitating doctor) you should {be begging?} for your				

		life ... there's always someone worse than you ...				
173	E	(continuing imitation) ... even if you can only move your eyelid...				

#	contributor	message	episode	episode focus	relation to previous episode	process
174		(5sec pause)				
175	E	*** there is no dispute...				
176	I	I mean this is so bad, she got 100 pounds				
177		[the students are making fun of the authorities' decisions in Mrs. B's case]				
178	C	yeah, that was sort of a nominal charge that the doctors had to pay for keeping her alive				
179	I	(ironically, reading partially from sheet) well done, Dame Elisabeth Butler {voss?} [presiding judge?]				
180		(all laughing)				
181	E	so what, sorry, ... so what, they turned it off and she died? [23:59]				
182	I	and they moved her to another hospital... which treat her according to her wishes, (ironical) I mean, ... so she has a, ... (again serious now) general statement iiiis...				
183	E	well done Dame Elisabeth ...	]			
184	I	she has a..., it is a life-threatening condition, general fact is that she had aahm, ... in advance {according to?} her wishes, * value is therefore that she should be followed and she should be allowed to die.	[23]	autonomy	other	relating aspect of concept (autonomy)
185	E	but the difference between the two cases is this one that they didn't have to intervene in order for her to die	[24]	similarities-differences	other	relating cases (active vs. passive euthanasia)
186	I	yeah, ... all they had do to turn off the ventilator, that's a treatment, they aren't actually, ... had to give treatment, yeah				
187	C + E	yeah				
188	E	so, this lady, Dame Elisabeth, who is clearly saying (3sec pause)				
189	E + I	(talking at the same time) ** consent ** [24:54]				
		(Nusha passes by, tells them to prepare for plenary)				

Appendix 5

The discussion of group 2 on the euthanasia cases.

The figures show the transcripts and the coding of processes and episodes (including the focus of an episode and its topical relation to the focus of the previous episode).

The notation used for the transcripts is described in appendix 4, page 264. Note: Peta is the tutor.

#	contributor	message	episode	episode focus	relation to previous episode	process
1	E	so it went to the high court, didn't it	[1	locus of judgment		
2	I	yes				
3	P	it's been through the several stages to get there.				
4	I	yes, but ultimately the central decision comes from the judge, doesn't it? .. or is it like a jury, that *				
5	P	jury, *, jury				
6	E	* jury and * -based, she just summarises it				
7	I	ok, fair enough, *, I just thought				
8	P	the thing is, *, it's the judge that makes this decision but the judge has the power to overrule that decision, if it's				
9		(interrupted by E, points at food)	]			
10	Peta	do you understand what you are doing, someone is going to be designated and notate that.	[2	task	other	
11		(decide on who takes notes)				
12	Peta	just remember that you have permission to think all around on the subjects, it's not black and white				
13	I	(addressing Peta directly) * just need to clarify this, *, aahm (looks at sheet), you know when the judge gives a decision, is that based on what the jury ...				
14	Peta	(sits down, joins the group) I don't know, I think in this case it is not a criminal aah, it's not in a criminal *				
15	I	(interrupting) so it's one ** ...				
16	Peta	yeah, she would have taken in all of the information, aahm, aahm, and I think the process was done {there?} for many weeks, wasn't it				
17	I	yeah				
18	C	it was very long				
19	I	So, ultimately it's the judge's value				
20	C, E, I	(laugh, smile immediately)				
21	Peta	well, she's ...				

#	contri-butor	message	episode	episode focus	relation to previous episode	process
22	I	*, just to make sure				
23	Peta	she's doing it from a legal point of view				
24	C	but it's * ...				
25	I	*				
26	Peta	so in actual fact, it's really reading the scenarios and trying to see the practical reasoning's pathway				
27	P	(addressing Peta directly) is it all right if we don't have like a set view ***?				
28	Peta	yes, I think, if you support ** ... that might be ** because we don't have enough information...	]			
29	P	basically, I just feel as I ... if I was in her situation I might have wanted what she wanted, but because I've never been there I don't know, and also, if we let her die, what, ... what is ** {the consequence???} of that and how many other people will be able to come up * with the same case?	[3	beneficence and universali-sibility	other	relating concepts (beneficence and universalisibility)
30	Peta	I think that's a, that's a very relevant point... [3:20]				
31	E	(consults sheet)				
32	C	it's...	]			
33	Peta	when you come to the end of discussing the trial, because there seem to *** judgement ***	([])			
34	C	(shakes head in disagreement) ... there is the difference, because [looks at sheet], because, basically, Mrs. Pretty, no, Mrs. B ... it is passive and they could just switch off the ventilator, because basically they are keeping her alive, aahm, without her will (Peta nod approvingly), ..., whereas the other one [Mrs. Pretty] was actually actively given drugs to die. So that's why it's difference there, and basically, why we are using like artificial, we're using like drugs to keep people alive against their will, without letting them die [4:05] ... naturally	[4	autonomy	conceptual contras-ting	relating cases (active vs. passive euthanasia)
35	P	(interrupting) and Mrs. B is similar to a coma				relating cases (one generic)

#	contributor	message	episode	episode focus	relation to previous episode	process
36	C	(continuing) and this is like, ... this is like natural death, isn't it (points to sheet), .. Mrs. B, is like natural death, ...?				
37	Peta	(nodding) yes.	]			
38	C	(continuing) whereas the other one was like actively killing her.	([5])	legality of euthanasia	semantic-associative	
39	Peta	now if you read the scenario, ..., you started off with Mrs. B....	[6	task	other	
40	All	yes				
41	Peta	... if you read the scenario with Mrs. B, the doctors didn't really agree, did they ?...				
42	E	they changed their mind, which was quite ...				
43	Peta	... they didn't seem to agree. So, in some sense, aahm, {through, in?} the eyes of the doctors, ... why {did they?} came {?}to that in the first judgement ** therefore ***	]			
44	P	the really silly thing they did, they didn't make enough of a fuss about it when she was actually in an able state to sort of disagree with them, they sort of let it only become an issue later where they, ..., 'cause, aahm, it says here (points to sheet) .. {such?} she wrote an advanced direct instruction, instructing the doctors, ... they should have like ...	[7	autonomy	other	relating aspect and concept (autonomy)
45	I	(interrupting) I think she was {a/of/in stable mind?}.				
46	Peta	yes				
47	P	yeah, exactly, but they didn't make like a huge fuss about it then. She shouldn't have been able to write that letter {and it/in it ?} actually mean something.				
48		[group seems a bit puzzled]				
49	E	(a bit agitated, pointing to the sheets) that's, that's, ... I mean, when she writes that I don't want this or I can't have a blood transfusion because of my religion ... then the doctor is bound by general law to follow the ...	]			relating cases (one generic)
50	Peta	* they'll get a judgement to actually override ...	([8	'power' of law	semantic-associative	
51	E	they can? A doctor can do that?				
52	Peta	yes, they can. ...				

#	contributor	message	episode	episode focus	relation to previous episode	process
53	I	Yes, when we at our GP placement, we had a patient, [that] afterwards wanted to ask the doctor something unrelated [to the thing she came into the practice in the first place], and she said, can my husband have access to my medical history, and he [the doctor] said, no, unless the court requests it for a specific reason, and she said, what about my son, and the doctor said, well, both parents can access [the son's medical history] if they do it properly				relating cases (no abstraction)
54	Peta	yeah, what is interesting *** later in the year, is that, related to what you (points to I) say, is that doctors have {several?} ** patient ** even after his death ** notes ** earlier on before this ... aahm ... ** and she would say *** when she was {conscious?) enough to say that, what was that the judge said, ... one of the key things for the judge was that ... Mrs. B., ... at the time * Mrs. B said * I don't want to *** key component.				
55	E	what was the key component?				
56	Peta	... and the judge ...	])			
57	E	that she has made an informed decision *** she was, she was (points to his head)	[9	autonomy	other	relating aspect to concept (autonomy)
58	P	... she was stable ...				
59	E	yes				
60	C	she was unstable ...				
61	P	she was stable at the point when she wrote the letter [6:55]				
62		(C writes down that she was stable [note that C keeps the record of the discussion])				
63	Peta	that was one thing that think came out really clearly at her video presentation that she was obviously extremely competent, extremely informed	]			
64	I	why is it that so many cases *****	[10	society's values	semantic-associative	
65	Peta	because we are allowed to. As I said, people's beliefs and values are now being allowed to {be out?} to the open public, whereas before, (theatrical) no, no, no, no **				

#	contributor	message	episode	episode focus	relation to previous episode	process
66	I	so they were almost scared to ask them [the questions] before, but now * ...				
67	Peta	I think, that ... yes ...				
68	C	morals have changed over time ...				
69	P	... * morally wrong				
70	E	they where a taboo...				
71	P	* ... what informed about these issues ...				
72	E	(addressed at Peta) what is your opinion, on assisted suicide? [8:00]				
73	Peta	***	]			
74	Peta	did you see the documentary on Mrs. B and Mrs. Pretty?	[11		other	
75	C	no				
76	Peta	if you saw it, then * {your?} judgement and listen to the chap from hospice *, you'd actually think, ** it would be {enough?} if she was allowed just {to?} drifting away ...	]	autonomy		
77	C	she knew what she wanted basically and she was gonna fight for it basically... but the thing is (looks at sheet) with Mrs. B, (Peta stands up, aiming to leave the group) she was very active before and suddenly there was a quick change where she could do nothing ...	[12	beneficence	conceptual contrasting	relating aspect and concept (beneficence)
78	Peta	in some sense, ... a doctor with a different hat on would say, I've got a patient that is paralysed from the neck down, he has no quality of life therefore I agree with you [on allowing him/her to die] ...				
79	C	you could sympathise ...				
80	Peta	... that would be one doctor's value, another doctor's value would be different. But that's an important thing to actually be able to say				
81	P	(talks separately to Peta)	]			
82	E	** trying to preserve the patient's life or something [1:30]	[13	'preserving life'	conceptual contrasting	
83	C	then * you are supposed to prolong her life artificially	]			

#	contri-butor	message	episode	episode focus	relation to previous episode	process
84	E	yeah, exactly, * ... *, let's just say you're [paralysed from the neck down]... you have to be fed through a tube, a what type of life is that (theatrical)	[14	beneficence	conceptual contrasting	relating aspect to concept (beneficence)
85	C	let me write that down (writes)				
86	I	my grandmother had terminal cancer basically, she couldn't move her headI just remember that it was extremely frustrating to be mentally sound and not being able to [move]				analogy ('quality of life')
87	P	especially if you've had that previously				
88	I	she used to be a chess champion ** ... but she couldn't move, and it was very frustrating. She used to say, it would be good to die because ...				
89	C	the thing is, you have to put yourself in their position, like, you can do it, ... how frustrating, like...				
90	I	I don't know how these psychiatrists would react if they would be in Mrs. B's position				
91	C	exactly... what's the point	]			
92		(3 sec pause)				
93	E	yeah but it's all about where you draw the line	[15	universalisibility	conceptual contrasting	
94	C	yeah, you're gonna draw the line ...				
95	P	the thing is, I know for a fact that, right ...	]			
96	C	it depends what they want as well [3:07]	[16	autonomy	conceptual contrasting	relating aspect and concept (autonomy)
97	P	after this case they must have got so many other people just requesting the same thing				
98	I	(interrupting) yeah, if this goes to the {front?}, everybody **...				
99	P	and they'll move further and further up as well				
100	C	ok, (writes) 'where to draw the line'				
101		(2 sec pause)				
102	I	yes, where do we draw the line, because as {you?} said...	]			
103	E	(interrupting) I think that's (points to the sheet [Mrs. B]) the right decision	[17	task	other	
104	P	that's the right decision ...				
105	C	that's the right decision	]			

#	contri-butor	message	episode	episode focus	relation to previous episode	process
106	P	...because that was a coma and * if someone is on life-support, I mean, families have the right to turn it off after a while * and she (points to the sheet) was in a fairly similar situation ...*	[18	nonmale-ficiance (families)	other	relating cases (one generic)
107	C	except that she could talk				relating aspect and concept (autonomy)
108	P	without that [the life-support] she was dead, so...[3:41]				
109		[4 sec pause]	]			
110	E	the one thing I was surprised about was that, she said the doctors applied to the court ... she signed that thing prior to her [condition], like, I know what's gonna happen, I gonna write now while I am in an informed {fine?} frame of mind, to say that, if it all goes [in the way it will, i.e. that she requires life-support], turn the ventilator off. And the doctors can take that piece of paper, the contract, take it to the high court and say ** ... . That's what I find quite odd, actually [that there is still a decision to be taken, if her will was it to die]	[19	autonomy	conceptual supporting	relating aspect and concept (autonomy)
111	I	because, I know someone who is a doctor and they had, *** had a huge motorcycle accident he actually{had to have?} blood transfusions, * but when it actually came out ** [that he was a Jehovah's witness] , ** how can a doctor try to preserve life ***				analogy
112		(E and I continue to discuss)	]			
113	C	(to P) do you actually all agree that it was the right thing to do [in Mrs. B's case]	[20	task	other	
114	P	yeah, to a certain extend [4:42]				
115	C	ok, you're kind of impartial at the moment				
116	C	I basically agree that it was the right thing to do because I don't want to be in this position	]			relating aspect and concept (beneficence)
117		(all together again)				
118	E	did you know that *** Jehovah's witnesses believe that the blood represents how good you have lived your life ...	[21	not relevant for cases	semantic-associative	
119	P	you see, that's the thing, body and soul are separated, I've got my donor card, ... it doesn't bond me where the rest of me goes [the soul?] ... I don't know, ...,	]			

#	contributor	message	episode	episode focus	relation to previous episode	process
120	E	what's the thing about in the GMC where it says to the doctor's, respect your patients' wishes...	[22	locus of decision making	other	
121	I	so, is this (points to the sheet) not going against the GMC ...				
122	P	that's what I thought...				
123	I	... because the GMC explicitly says ..				
124	P	... you know you've also got a right ...				
125		(3 students looking into sheets)				
126	I	it must have gone to the GMC [Mrs. B's case, here GMC refers to a panel of experts (doctors and/or judges)], ... it's such a high-profile case				focus on general knowledge (GMC competencies)
127	P	no, but think about it, the doctors who are involved [in Mrs. B's case] are all qualified because of the GMC, so it [the GMC] is directly involved.				
128	E	you see, what you've got to bear in mind is that balance between trying to give the best care to the patient, you se, that's the thing.	([23])	dilemma	semantic-associative (from GMC to doctor's duties)	relating concepts ('doing good' and 'preserving life')
129	I	yes it's true, ** GMC ** contradictory * ...				
130	P	(nodding) it is [contradictory] [6:24]. It's like one point ** [refers probably to a list in the GMC] and they like do it directly under {each?} other as well ?				
131	E	there's nothing ** in the GMC **				
132	P	should we read the other (turns sheet) as well?	([])			
133	I	it's such a high-profile case, {whereas?} the doctors * opinion *				focus on general knowledge (chain of responsibility)
134	P	no, it's not about they're getting involved in any other way as opposed to analysing ... the way the doctor are working...				
135	C	.. the doctors [in Mrs. B's case] must have consulted someone, so who did they consult?				

	contributor	message	episode	episode focus	relation to previous episode	process
136	E	well, they would have been consultants, would they				
137	I	I would have thought that the whole * process would have been funded through the GMC, so the GMC * ...				
138	I	we should bring that up in the discussion with everybody ...				
139	C	let's just say, did it go though the GMC (writes it down)?				
140	I	we should bring up the two points. Wishes of the patient and preserving life ...				relating concepts (autonomy and beneficence)
141	E	yeah, respecting the patient's wishes and views and things which is what the {problem?} (points to sheet) was about.				
142	I, E	GMC has absolute power, it's quite scary...	]			
143	P	should we look at Mrs. Pretty's case?	[24	task	other	
144		(group discusses opinions about the GMC, it's features, composition, implication for the public, and so on)				
145	C	ok, Diane Pretty * asking doctors to help her die				
146	P	yes, but if she says this one, I don't think there is anything particularly wrong with it. (cites from sheet) "I'm fully aware what the future holds and I've decided to refuse artificial ventilation", isn't that what the other {lady?} did?				relating cases (abstracting similarity)
147	E	yes				
148	P	so why is it, ..., she's not asking for it now, is she?				
149	E	yes, but then later on it got really bad, and she said, I want it now.	]			relating aspect and concept (beneficence)
150	C	a doctor is gonna help her to die, and how is she's gonna {find?} this doctor, because I wouldn't ...	[25	legality of euthanasia	semantic-associative	
151	P	(interrupts) and how's this doctor not gonna get convicted for anything if he helps her to die,				
152	C	I wouldn't				
153	E	He would get convicted because it's against our law, but in the Netherlands, there's a machine that [kills someone] and there's a button ...				

#	contri-butor	message	episode	episode focus	relation to previous episode	process
154	C	yes, but who's going to press that button				
155	E	well				
156	C	that's the thing, the responsibility of that person. I wouldn't want to be held responsible for like killing a person. [4:47]				
157	E	that's were the problem was (points to sheet). She [Mrs. Pretty] almost interfered with what her husband's civil rights, because she is asking someone else, in effect, to commit murder.	[26]	civil rights	semantic-associative	
158	P	and also, I am a bit ***, what if some * comes along and kills **	[27]	universa-lisibility	semantic-associative	
159	C	the thing is...				
160	P	there must be some form of treatment that might {find?} ** research stages				
161	E	it probably hasn't made it into a bedside yet	]			
162	C	(cites from sheet) her muscles are being destroyed...	[28	benefi-cence	conceptual contrasting	relating aspect and concept (beneficence)
163	P	I wouldn't wanna be living like that ** being dependent on someone **				
164	C	that's what she wanted, when her mind was like still good, she wanted to die like that, ... like my elderly neighbour, she wanted to die like, ...** ... memory, she didn't want to have her memory wasted weight, she didn't wanna waste weight [???], ... and at the end she wanted to like die sooner...				analogy ('quality of life')
165	P	(looked at sheet before, now raises her head] yeah, that's the thing, she [Mrs. Pretty] is depending on other people [6:15], ... and they could easily have just left her.				
166	C	does she have family?				
167	P	yeah				
168	E	I thought they did do that [?]				
169	E	well she didn't want to die from choking or whatever, but wanted to go peacefully, quietly at home with her family..... Hmmm, it's a difficult one				relating aspect and concept (beneficence)
170		[6:50]	]			
171	Peta	(passes by) can I just ask you to come to a conclusion now?	[29	task	other	
172		[5sec pause]				

#	contributor	message	episode	episode focus	relation to previous episode	process
173	E	my conclusion is that Mrs. B didn't get enough money. She shouldn't have got only 100£.				
174	C	what is the trespass there (points at the sheet)?				
175	E	basically they gave her treatment ...				
176	C	ha, ha, ha, a 100£?				
177	P	was this after she had died?				
178	E	no, this was before she died				
179	P	(joking) hey, come on, that's an improvement of what they would have done normally				
180	E	(smiles)				
181		(some jokes)	]			
182	E	the only difference [between the two cases] is that she [Mrs. Pretty] wanted to end her life and it meant involving someone to commit ...	[30	nonmale-ficiance	other	relating cases (abstracting 'active vs. passive euthanasia')
183		***				
184	P	that is a big difference				
185	E	that's a huge difference	]			
186	P	... but then why is it a huge difference, if her [should be or is "their"]quality of life otherwise would have been the same? ... ... Because that one (points to a spot on top of the sheet (S1)) is not moving, and this one (points to another spot (S2) at the bottom of the sheet) is not moving, and this one is talking (points to S1), no, she (points to S2) is talking, she (points to S1) is ... kind of talking.	[31	beneficence	conceptual contrasting	relating cases, (abstracting 'quality of life')
187		(3sec pause, puzzling)				
188	E	yeah, but, she (points to spot 1) just wanted, ..., no she didn't want, but she was aware that her disease would lead its final course, and when this happened she didn't want the medical profession to interfere, whereas this one (points to S2) was like, I need to sort it out now, because this is just				relating cases, (abstracting 'autonomy')
189	P	she (points to S1) was asking to interfere earlier				
190	P	it's really bad that they don't even have that much sort of control over their life; she wanted to commit suicide ...				relating aspect and concept (beneficence)

#	contributor	message	episode	episode focus	relation to previous episode	process
191	C	but she couldn't				
192	E	she didn't have the physical ability to do it.	]			
193	P	committing suicide isn't legal anyway	[32	suicide	semantic-associative	
194	E	it is.				
195	C	it is not.				
196		(Peta passes by)				
197	Peta	you can't be arrested when you commit suicide, can't you?				
198	E	but it's your right to take your own life.				
199	C	it's not your right				
200	P	if it's your right to take your own life then (points to sheet) it's her right to die				
201	E	that's the whole argument	]			

Appendix 6

Task context of the discussions on the medical law cases

Welcome to our study on learning medical law

(1) you'll be shortly given a questionnaire on your computer literacy. Please answer it in not more than 10 min.

(2) we'll tell you when to start reading and discussing the first case.

(3) in most cases, you'll be given the verdict of a judge.

Task: your task is to explain and understand the verdict, by discussing how the judge arrived at his decision, given the information available. In doing this, try to (1) **avoid speculating about further facts**, and (2) **avoid speculating what the doctor should have done**.

Once you're feel that you have **covered all the relevant aspects of the case**, send a 'ready' through the chat. Take your time to discuss, don't hurry!

Appendix 7

Background material to the cases on medical law.

This text was given to the students to read (for 5 minutes) at the beginning of each learning session. The text could be accessed through a hyperlink at any time during the discussion.

Summary on the concepts of negligence and liability

Lawyers use the general idea of 'a duty of care' which means that everyone has a duty to avoid harming others. Doctors are seen as having a special duty of care towards patients by virtue of the general and specialist medical skills which they possess.
If a doctor behaves in a way which is not professionally responsible, then he may fail to maintain the duty of care he has for a patient, and he may then be judged to be negligent. Being negligent may involve following some form of action, or it may involve not following some form of action.

Lawyers make a distinction between negligence and liability: you may be judged to be negligent but not liable for what happened to a patient. To be liable for the consequences of their negligent actions, it would have to be shown that if the doctor had not acted in a certain way then the harm would not have taken place. However, if the doctor couldn't have been expected to see the outcome because it was too unlikely or too remote from the situation he was in, then even if damage resulted, he wouldn't be held responsible.

So how can we assess (i) whether the professional behaviour of the doctor was irresponsible, (ii) whether the damage which resulted from this irresponsible behaviour was really down to him/her? We have to rely on medical judgement, in both cases. Lawyers refer to the way this standard of professional medical practice is assessed as the application of the 'Bolam test'. But just as lawyers need doctors' advice, so doctors need lawyers' analytical skills and any medical opinion might need to be examined for its appropriateness and logic, in the particular circumstances of the case in question.

Appendix 8

The case of Mrs. Vadera

Vadera vs. Shaw

A 22-year old Asian woman presented herself 3 times within a year at her GP's practice, with the intention of starting contraception before she got married. She was to be married on 30th of November and was eager to start the contraception. She was warned that there were health risks associated with contraception pills. On the last visit, on 11th of October, her blood pressure was taken and it was at 150/100 (higher than normal for a woman of her age). This high reading was taken by the GP (Dr. Shaw) as a symptom of 'white-coat hypertension', a phenomenon cause by anxiety that occurs in a doctor's presence that can however also be indicative of a general tendency to hypertension. The next day, she started the pill. She claims that within 3 weeks she returned to the GP complaining about headaches and feeling generally ill. She says the GP prescribed her a medication for the headache. The GP claims this meeting had not taken place. {the records of meetings of that period had been destroyed} A week later, the plaintiff was admitted to the hospital suffering from numbness and difficulty in walking. Her BP was read several times and was at 170/110, 110/60 and 140/110. She then suffered a stroke that left her completely paralyzed (apart from the eye muscles).

Two instances did not find the GP negligent.

<u>Additional information</u>

The judge ruled that (i) there was no evidence of hypertension; (ii) that he did not believe the patient had headaches after commencing the treatment; and (iii) that the statistical evidence, as such, did not link taking contraceptives with stroke, over the population as a whole.

Appendix 9

The case of Mrs. Chester

Chester vs. Afshar

Miss Chester suffered from chronic back pain and consented to neurological surgery, on the recommendation of Mr Afshar; and the surgery took place within 3 days. After the surgery, she had extensive motor and sensory impairment. The kind of surgery done, it was accepted, carried some unavoidable risks and a one to two per cent chance of serious complications. It was also accepted that a patient such as Miss Chester should be informed of those risks.

The extent of this warning was disputed. The doctor claimed she had been warned adequately. Miss Chester countered that her fears about being 'crippled' were brushed aside and she had been told that the operation was merely a routine procedure. She went on to claim that if she had known about these risks she would not have agreed so easily to surgery without giving it more thought and/or seeking a second opinion.

The defendant argued that he could not be held responsible unless Miss Chester could prove that alternative advice would make her refuse ever to undergo the surgery in question.

The judge held that no negligence was involved in the actual operation but he sided with Miss Chester about the pre-operative advice. He also decided that the doctor was directly enough responsible to have acted negligently in giving his advice.

<u>Additional information</u>

(a) She had complained at an early stage after the operation about lack of adequate warning of risks

(b) There was evidence of her aversion to surgery – judged unlikely to be so reduced in three days, if she had been adequately informed of the risks

Appendix 10

The case of Patrick Bolitho

Bolitho v City & Hackney HA

Patrick Bolitho was a 2 year old child admitted to hospital with breathing difficulties. A day later his breathing deteriorated, and a nurse called the paediatric registrar, Dr Horn. The doctor said she would attend as soon as possible, but she didn't. However, Patrick recovered. At 2.00 in the afternoon he became ill again with breathing problems. The doctor was called, but again failed to attend. Unfortunately, at 2.30pm he collapsed. His respiratory system failed, and his heart stopped and caused 'catastrophic' brain damage. The claim was that the defendants were responsible for the brain damage which was caused by the heart stopping.

The hospital admitted negligence on the part of Dr. Horn for not attending or for not arranging someone else to attend the child. They denied liability because, even if Dr Horn had attended she would not have intubated the child – not before 2.30pm. The judge accepted that Dr. Horn would not have intubated the child. the question for him was: should she have? There were five experts for the plaintiff who said that, in the circumstances, respiratory collapse should have been envisaged, and Patrick should have been intubated to prevent that happening. However, the three experts for the defendant said that apart from the acute episodes the child seemed quite well, and intubation was not without risk. The judge found that the two leading witness for each side were absolutely opposed, and the defendant's witness was "an especially impressive witness". Both represented a responsible body of professional opinion. So, he applied the Bolam test, acknowledging that it was not for him to prefer one respectable body of opinion over another. The judge found for the defendant. The case went to appeal and the original decision was upheld.